Proposed
TOTAL MAXIMUM DAILY LOAD (TMDL)

For

Metals, Pathogens and Turbidity

In the Hurricane Creek Watershed

Tuscaloosa County, Alabama

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United States
Environmental Protection
Agency

Region 4
serving the
southeast

Under the authority of Section 303(d) of the Clean Water Act, 33 U.S. Code §1251 et seq., as amended by the Water Quality Act of 1987 (PL 100-4), the U.S. Environmental Protection Agency is herby proposing TMDLs for the following waterbodies and causes in the Hurricane Creek watershed:

Hurricane Creek Watershed
Metals (Aluminum, Iron)
Pathogens
Turbidity

Little Hurricane Creek Watershed
Metals (Aluminum, Iron, Copper)
Pathogens

North Fork Hurricane Creek
Metals (Aluminum, Iron)

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EXECUTIVE SUMMARY

The Alabama Water Quality Report to Congress for 1994-95 identified 19 miles of Hurricane Creek as not supporting its designated use of Fish and Wildlife due to metals, low pH, siltation, and organic enrichment/D.O (ADEM 1996). This information qualified Hurricane Creek for inclusion on Alabama's 1996 303(d) list. The listing decision was based on biological assessments that indicated impairment of fish and benthic macroinvertebrate communities within the watershed. The sources of these impairments were attributed to surface and subsurface mining, and mill and mine tailings. Additional water quality sampling resulted in three waterbodies in the Hurricane Creek watershed being placed on Alabama's 1998, 2000, and 2002 303(d) lists. The mainstem of Hurricane Creek, from the Black Warrior River to its source, was listed as impaired due to turbidity, pathogens, aluminum and iron. Little Hurricane Creek, a major tributary that drains the southeastern portion of the watershed, was listed for aluminum, arsenic, copper, chromium, iron and pathogens. North Fork Hurricane Creek, another important tributary that drains from the northeast, was identified as impaired for aluminum. The Alabama Department of Environmental Management (ADEM) attributed the metals impairments to acid mine drainage (AMD) from abandoned surface mines. The turbidity impairments have been attributed to mining, silviculture, and land development, while the probable sources of pathogens are nonpoint runoff from failing septic systems, pastures and croplands, or residential and urban areas.

EPA developed TMDLs for Hurricane, Little Hurricane, and North Fork Hurricane Creek and released the proposed TMDLs for public review and comment in July 2001 (U.S. EPA. 2001). ADEM and other stakeholders responded with substantial comments. In consideration of these comments, EPA decided to collect additional data and revise the TMDLs. This report is a reproposal of those TMDLs.

The July 2001 TMDLs were developed from a dynamic watershed model using the Loading Simulation Progam C++ (LSPC). However, many of the technical concerns raised regarding those TMDLs involved the modeling assumptions that were made, and the difficulty of adequately modeling the hydrology of Hurricane Creek given the sometimes flashy nature of its streamflow and the lack of recent, continuous flow data. The revised TMDLs for metals, pathogens and turbidity are developed using empirical approaches based on in-stream water quality data collected from a variety of sources. Although no waterbody in Hurricane Creek is currently 303(d) listed for pH, these data document pH excursions in some tributaries of the watershed. Given these excursions, and the strong relationship between pH and concentrations of total metals, as well as their dissolved fractions, the TMDLs for iron use a dual target that is dependent on pH. Because iron and aluminum appear to be coming from the same sources and both metals have a similar relationship to pH conditions in the stream, achieving the allocations provided for total iron will also ensure protection against impairment associated with total aluminum. After evaluating the available data for arsenic and chromium, EPA determined that no waterbody of Hurricane Creek is currently impaired for either metal, so TMDLs to address them are not needed.

The sources of water quality data used to develop these TMDLs include ADEM data from four days in June and August 1996, and from ten dates between June 2000 and October 2002. Water quality measurements made by the Alabama Rivers Alliance

(ARA) in May through August 2000 were also used where applicable (Wentzel and Duncan 2001). In addition, data from the water quality sampling that EPA conducted throughout the Hurricane Creek watershed in August 2002 are incorporated in the TMDL assessment. The results of the EPA study are summarized in the Hurricane Creek Watershed Water Quality Sampling Report (U.S. EPA. 2003).

TMDL SUMMARY TABLES

TMDL Allocations for Metals

waterbody	Waste Load Allocation					Load Allocation			Margin of Safety	TMDL	
	MS4		FACILITY[1]								
	pH s.u.	Fe/Al P.R.	pH s.u.	Fe[2] mg/l	Cu[3] mg/L	pH s.u.	Fe/Al P.R.	Cu P.R.		Fe/Al P.R.	Cu P.R.
Hurricane Creek	6-8.5	75%	6-8.5	3.45	NA	6-8.5	75%	NA	implicit	75%	NA
Little Hurricane Creek	6-8.5	NA	6-8.5	3.45	0.004	6-8.5	86%	33%	implicit	86%	33%
North Fork Hurricane Creek	6-8.5	NA	6-8.5	3.45	NA	6-8.5	98%	NA	implicit	98%	NA

1. The Facility Waste Load Allocation (WLA) applies to individual NPDES permitted facilities, including non-MS4 regulated stormwater dischargers. For continuous dischargers, the WLA shall apply to a four-day average concentration. For wet weather dischargers, the WLA shall apply to an event mean concentration.
2. The WLA for aluminum is a narrative that assumes meeting the WLA for iron and pH will inherently protect for aluminum.
3. The WLA for copper is equivalent to the hardness-based chronic criterion. The number in the table is calculated from the lowest measured hardness for any station on Little Hurricane Creek (27 mg/L $CaCO_3$).
4. Abbreviations: Fe = total iron; Al = total aluminum; Cu = total copper; s.u.= standard units; P.R. = percent reduction..

TMDL Allocation for Turbidity

Waterbody	Waste Load Allocation		Load Allocation[2]	Margin of Safety	TMDL
	MS4 P.R.	Facility[1] NTU	P.R.		P.R.
Hurricane Creek	32%	60.8	32%	implicit	32%

1. The Facility Waste Load Allocation applies to individual NPDES permitted facilities, including non-MS4 regulated stormwater dischargers. The average turbidity associated with the discharge for a storm event shall not exceed this limit.
2. The turbidity levels of all waters originating from non-point sources shall not exceed 60.8 NTU.
3. Abbreviations: P.R. = percent reduction; NTU = Nephelometric Turbidity Units.

TMDL Allocations for Pathogens

Waterbody	Waste Load Allocation			Load Allocation	Margin of Safety	TMDL
	MS4	Facility[1] (colonies/100ml)				
	P.R.	Jun. - Sept.	Oct. - May	P.R.		P.R.
Hurricane Creek	67%	200	1000	67%	implicit	67%
Little Hurricane Creek	NA	200	1000	25%	implicit	25%

1. The Facility Waste Load Allocation (WLA) applies to individual NPDES permitted facilities, including non-MS4 regulated stormwater dischargers. The Facility WLAs are "end of pipe" limits of the monthly geometric mean concentration of fecal coliform bacteria. These values are equivalent to the State's Water Quality Standards for fecal coliform bacteria. Future facilities that discharge fecal coliform at or below Water Quality Standards should not cause or contribute to impairment. It is assumed that by meeting the geometric mean 30-day concentration, the instantaneous standard of 2000 colonies/100 ml will not be violated.
2. Abbreviations: P.R. = percent reduction.

1.0 Introduction

TMDLs are required for impaired waters on a State's Section 303(d) list as required by the Federal Clean Water Act Section 303(d) and implementing regulation 40 CFR § 130. A TMDL establishes the maximum amount of a pollutant a waterbody can assimilate without exceeding the applicable water quality standard. The TMDL then allocates the total allowable load to individual sources or categories of sources through wasteload allocations (WLAs) for point sources, and through load allocations (LAs) for non-point sources. In the TMDL, the WLAs and LAs provide a basis for states to reduce pollution from both point and non-point source activities that will lead to the attainment of water quality standards and protection of the designated use. The 303(d) listed waterbodies and impairments for Hurricane Creek are summarized in Table 1. It should be noted that this report does not provide TMDLs for arsenic or chromium for Little Hurricane Creek, because the available water quality data do not indicate current impairment from those metals. A TMDL for iron is also provided for North Fork Hurricane Creek because the data show iron excursions in its upstream Weldon Creek tributary, and because the percent reductions for iron are being used to quantify the percent reductions for total aluminum.

Table 1. 303(d) Listed Waterbodies and Impairments

Listed Segment ID	Stream Name	Length (mi)	Designated Use	Impairments	Sources
AL 03160112-120 01	Hurricane Creek	31.4	Fish & Wildlife	Aluminum, Iron, Pathogens, Turbidity,	Surface mining-abandoned, Land development
AL 03160112-120 02	Little Hurricane Creek	10	Fish & Wildlife	Aluminum, Arsenic, Copper, Chromium, Pathogens, Iron	Surface mining-abandoned
AL 03160112-120 03	North Fork Hurricane Creek	6.4	Fish & Wildlife	Aluminum	Surface mining-abandoned

2.0 Watershed Characterization

Hurricane Creek is located entirely in Tuscaloosa County in north-central Alabama. The drainage area of the watershed is approximately 116-square miles (74,329 acres). From its headwaters, Hurricane Creek flows westerly for about 31 miles until its confluence with the Black Warrior River north of the city of Tuscaloosa. The major tributaries to the main stem are the North Fork Hurricane Creek, Little Hurricane Creek, Kepple Creek, Bee Branch and Cottondale Creek *(*Figure 1*)*.

The watershed is located within the outcrop of the Pottsville Formation of Pennsylvanian age, which contains coal seams that have been extensively mined, producing surface water pollution and acid mine drainage problems (Geological Survey of Alabama 1999). The watershed is dominated by forested lands and areas disturbed by coal-mining activities (U.S.EPA 2000). Mined areas include active and inactive facilities as well as abandoned sites. Other land uses in the watershed include silviculture, and to a lesser extent, agriculture, industrial development, and residential development. The watershed's population is widely distributed throughout small towns and rural communities. The largest towns in the watershed include Vance, Brookwood, and the outskirts of the City of Tuscaloosa.

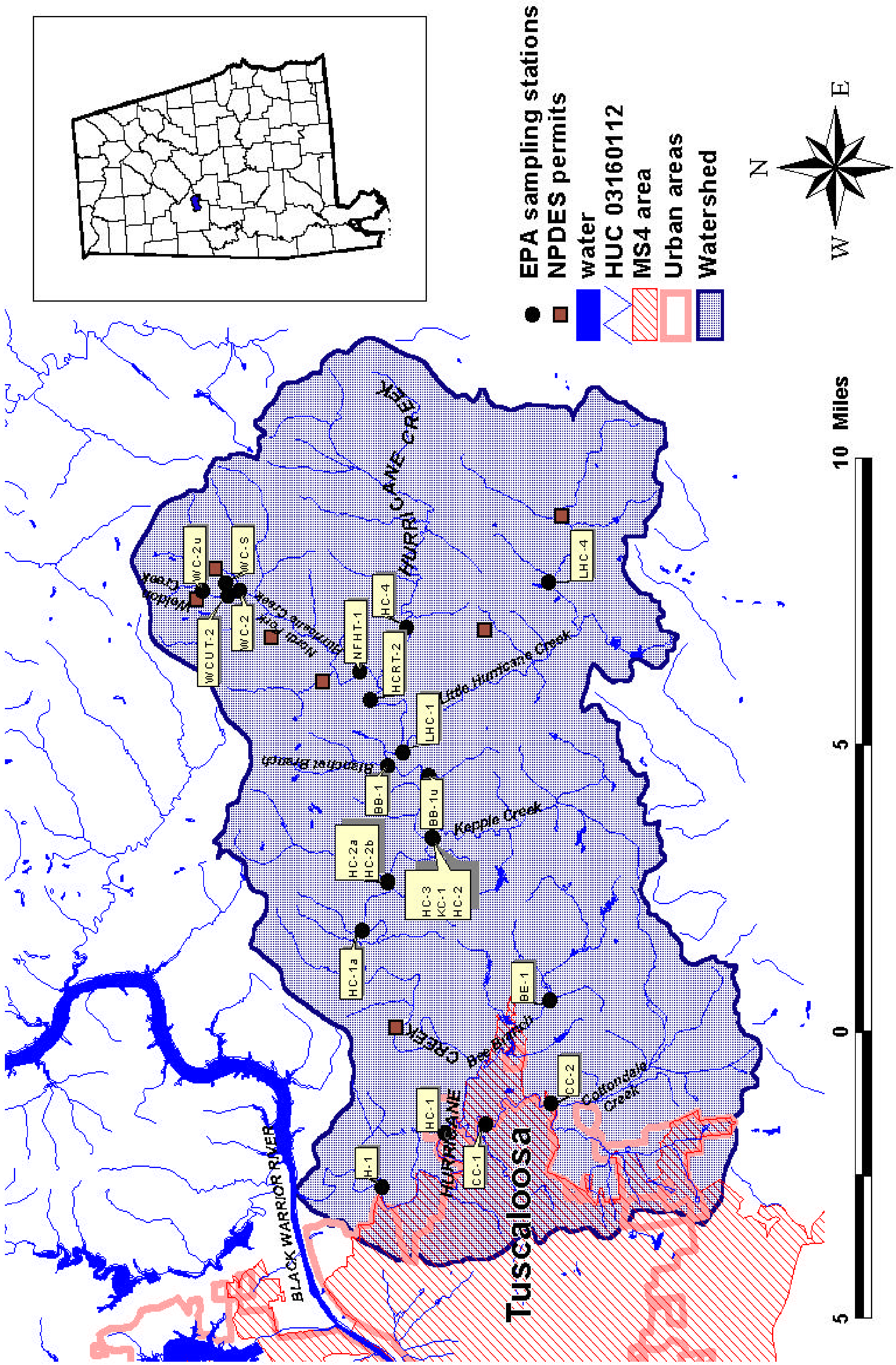
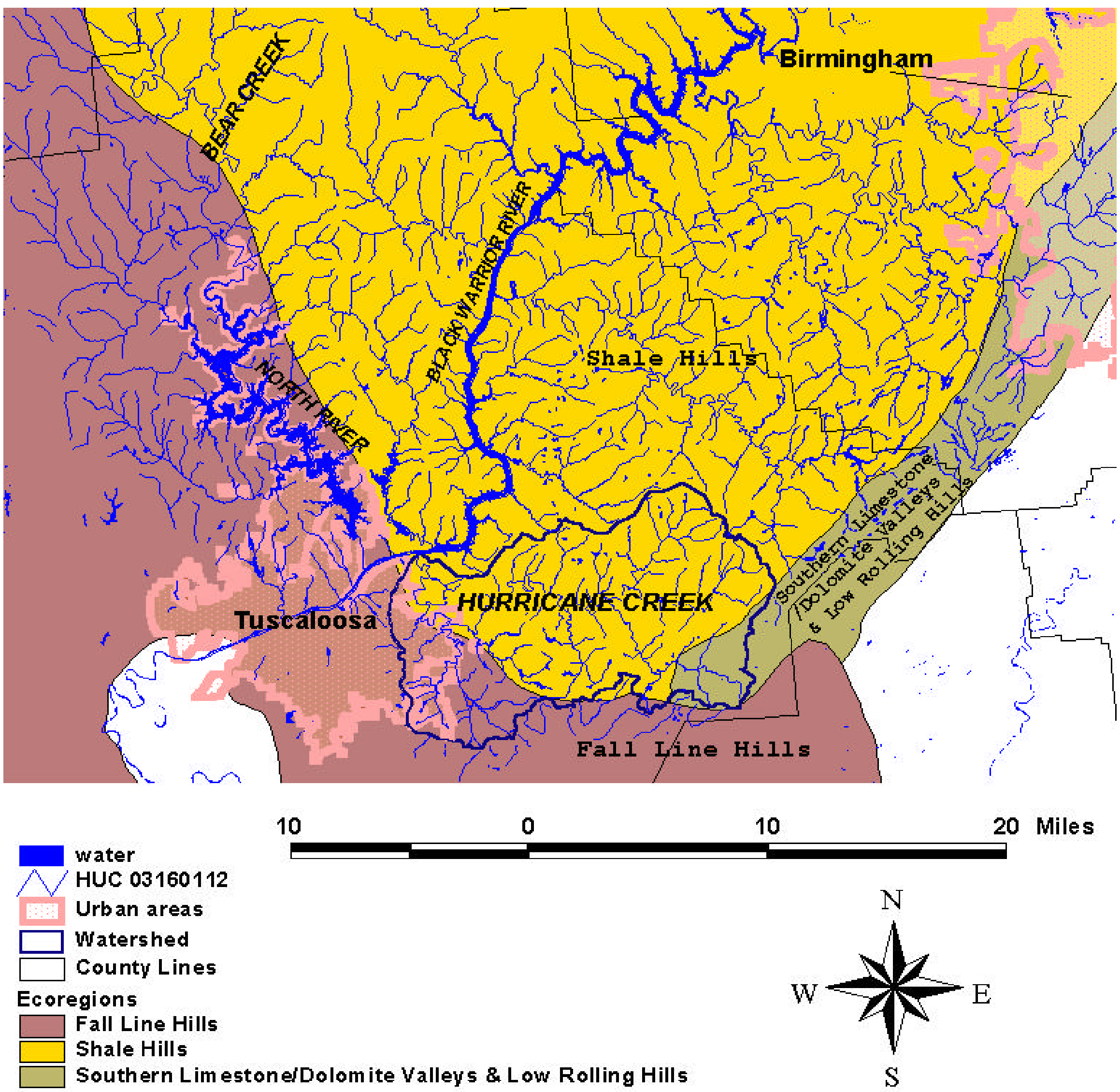


Figure 1. Location of the Hurricane Creek Watershed.

The mid and upper portions of the Hurricane Creek watershed fall within the Shale Hills (68f) Ecoregion, which is also known as the Warrior Coal Field (Griffith et al. 2001). Ecoregions denote areas of general similarity in ecosystem characteristics, including the geology, topography, hydrology and soils, etc. The topography of the Shale Hills is characterized by extensive hills with many strong slopes. Streams draining the relatively impermeable shale, siltstone, and sandstone bedrock generally have very low baseflow. The soils of the Shale Hills Ecoregion are typically silt loams with a silty clay or clayey subsoil. The lower part of the watershed, including Cottondale Creek, falls within the Fall Line Hills (65i) Ecoregion. The Fall Line Hills also has many slopes, but the sediments are more loamy or sandy than the Shale Hills. The headwaters of Little Hurricane Creek may encroach into the Southern Limestone/Dolomite and Low Rolling Hills (67f) Ecoregion. As the name implies, this region is characterized by rounded ridges and undulating valleys. The bedrock is predominately limestone and cherty dolomite that has many caves and springs (Figure 2).

Figure 2. Ecoregions of the Hurricane Creek and Bear Creek Watersheds.



3.0 Identification of Targets

The water use classification for all streams within the Hurricane Creek watershed is Fish and Wildlife (Alabama Administrative Code Rule 335-6-10-.09(5)(a), (b), (c), and (d)). According to the state water quality criteria, the best use of these freshwaters is for fishing, propagation of fish, aquatic life and wildlife propagation. The regulations also allow that incidental water contact and recreation during June through September are to be protected.

TMDLs are calculated to ensure that a waterbody meets applicable water quality standards. The applicable standards may be numeric or narrative in nature, or they may be represented by other indicators that demonstrate support of beneficial uses. The numeric target identifies the specific goals or endpoints for the TMDL that equate to attainment of the water quality standard. The numeric target may be equivalent to a numeric water quality standard where one exists, or it may represent a quantitative interpretation of a narrative standard. The following sections review the applicable water quality standards and identify appropriate numeric targets for calculation of the TMDLs for metals, pathogens, and turbidity.

3.1 Applicable Water Quality Standards for Metals

Alabama Administrative Code Rule 335-6-10-.07(1)(a) describes the chronic and acute criteria for toxic pollutants, such as trivalent chromium and copper, for which the numeric criteria are dependent on the hardness of the water. Hardness is a measure of the quantity of divalent ions, of which calcium (Ca^{2+}) and magnesium (Mn^{2+}) are the most common. Since hardness can be contributed by a variety of ions, it is usually expressed as the equivalent quantity of calcium carbonate ($CaCO_3$). Acute criteria are one-hour average concentrations not to be exceeded more than once every three years on average. Chronic criteria are four-day average concentrations not to be exceeded more than once every three years on average. The criteria for these toxic pollutants are applicable to all state waters:

Table 2. Water Quality Criteria for Copper and Trivalent Chromium

Parameter	Acute	Chronic
Copper, Total (µg/L)	$e^{(0.9422[\ln(hardness)]-1.464)}$	$e^{(0.8545[\ln(hardness)]-1.465)}$
Chromium, Trivalent (µg/L)	$e^{(0.8190[\ln(hardness)]+3.688)}$	$e^{(0.8190[\ln(hardness)]+1.561)}$

Assuming a hardness value of 50 mg/L $CaCO_3$, the acute copper criteria would be 9.2 µg/L and the allowable chronic concentration would be 6.5 µg/L (1000 µg/L = 1 mg/L). The chromium criteria would be 984 µg/L for the acute, and 117 µg/L for the chronic, concentrations, assuming the same hardness value of 50 mg/L. Measurements of hardness for each sample were used to establish the applicable criterion for each sample.

Arsenic is also a toxic pollutant, but its criteria are not dependent on hardness. For trivalent arsenic in freshwater, the acute criterion in Alabama Administrative Code Rule 335-6-10-.07(1) is 360 µg/L, and the corresponding chronic criterion is 190 µg/L.

The state of Alabama does not have numeric criteria for aluminum and iron. The EPA National Recommended Water Quality Criteria for both metals are provided in Table 3. Please refer to the following section for a more detailed explanation of the interpretation for iron and aluminum.

Table 3. National Recommended Water Quality Criteria for Aluminum and Iron

Parameter	Acute	Chronic
Aluminum, Total (mg/L)	0.75	0.087
Iron, Dissolved (mg/L)	-	1.0

3.2 Identification of Numeric Targets for Metals

Most of the listed metals have both chronic and acute criteria. Chronic criteria are generally more stringent targets, since they are intended to protect the health of aquatic life from chronic exposure to a particular pollutant. For copper and chromium, the hardness-based chronic criteria were used to evaluate the data. The applicable criterion for each sample was calculated from its measured hardness. For arsenic, the chronic criterion of 190 µg/L was selected as the target concentration.

Although no waterbody in Hurricane Creek is currently 303(d) listed for pH, the available water quality data document low pHs in some tributaries of the watershed. The concentrations of total metals, as well as the dissolved fraction of the total, are strongly affected by low pH conditions. As such, iron impairments were evaluated against dual targets dependent on pH. The dual targets are based on a translation of the EPA National Recommended chronic criterion for dissolved iron of 1 mg/L (Table 3). Data from a tributary to North Fork Hurricane Creek and from Bear Creek, the candidate reference stream for the Shale Hills Ecoregion, were used to convert the single target for chronic concentrations of dissolved iron into dual targets for total iron under given pH conditions.

Dissolved forms of metals are much more toxic than particulate forms because they are easily adsorbed or taken up across gills. Measurements of dissolved metals are considered to be a better indication of the fraction of total recoverable metals that would be biologically available and therefore potentially toxic to aquatic life (U.S. EPA. 1996). However, most water quality analyses measure the total recoverable amount of a given metal, and so the targets are usually stated in those terms. The fraction of total recoverable metal present in dissolved form will also depend on other conditions such as the water temperature, hardness, and concentrations of total suspended solids and organic carbon. However, when pH is low it is a dominant factor.

Studies in which both the total and dissolved amounts of a metal have been measured on the same sample may provide estimates of the expected dissolved fraction of that metal. Since March 2002, ADEM has been collecting data on Bear Creek, a tributary to the North River in northern Tuscaloosa County. Bear Creek is being considered as a candidate reference site for the Shale Hills Ecoregion, the same region in which Hurricane Creek is located (Figure 2). During a reconnaissance survey conducted by ADEM in the late 1990s, Bear Creek was judged to be the "least impacted" stream in the Shale Hills Ecoregion of Alabama. Neither ADEM, EPA, nor the Alabama Surface Mining Commission could find any evidence of past or present mining activity in the watershed. The landuse of Bear Creek is approximately 93% forested, 2% agricultural, and 5% transitional (V. Hulcher, personal communication 10/14/03). ADEM has periodically sampled Bear Creek, and measured both total and dissolved iron (Fe), among other parameters. The Bear Creek data show that, on average, about 30% of the total iron was dissolved (Table 4). The average dissolved fraction from Bear Creek will be used to represent Hurricane Creek when the pH is above 6.

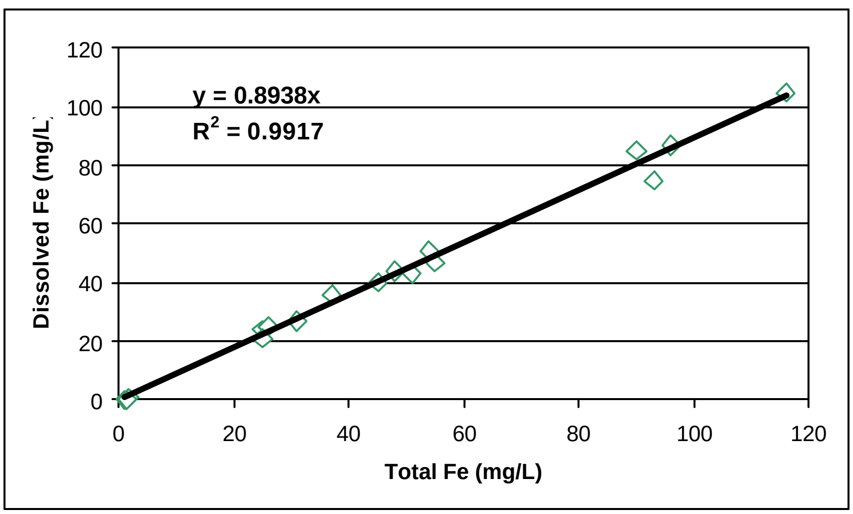
Table 4. Bear Creek Data for Total and Dissolved Iron (Fe)

Date	pH	Fe, Total (mg/l)	Fe, Dissolved (mg/l)	Dissolved Fraction
3/20/2002	7.1	0.336	0.1[a]	0.30
4/18/2002	6.9	0.463	0.103	0.22
6/6/2002	8.1	0.934	0.405	0.43
7/2/2002	8.6	0.771	0.109	0.14
8/8/2002	8.7	2.220	0.769	0.35
average				**0.29**

a = method detection limit

The Alabama Rivers Alliance (ARA) has been conducting a water quality study in the Weldon Creek area of Hurricane Creek. Weldon Creek is a tributary that drains directly to North Fork Hurricane Creek. The purpose of the study is to monitor the effects of an on-going restoration project in that watershed. Since May 2001, the ARA has been periodically collecting water samples from stations located in Weldon and North Fork Hurricane Creek. They have contracted with an environmental testing laboratory to have total and dissolved metals measured on the samples. The data show that the dissolved fraction of iron has consistently been about 90% in Weldon Creek (Figure 3). Just as the dissolved fraction for iron from Bear Creek will be assumed to represent the dissolved fraction of Hurricane Creek when the pH is near neutral, the dissolved fraction measured in Weldon Creek will be used to characterize waterbodies in Hurricane Creek when the pH is below 6. Most of the acidic pHs recorded in the watershed have occurred in the Weldon Creek area.

Figure 3. Total and Dissolved Iron Data from the Weldon Creek Restoration Project



Using the above dissolved fractions to translate the National Recommended dissolved iron criterion of 1 mg/L to values based on total recoverable iron, the targets would be 1.12 mg/L total iron when pH is below 6, and 3.45 mg/L total iron when pH is above 6. The target for pH>6 encompasses the range of total iron values measured by ADEM in Bear Creek.

Although there is a recommended chronic criterion for total aluminum, the reference stream data from Bear Creek, an unmined watershed, indicate that background concentrations of total aluminum frequently exceed that value in this region. As additional water quality data are collected on Bear Creek it should be possible to determine eco-regional criteria for aluminum and other metals. In this analysis, it is assumed that achieving the allocations for total iron will protect against impairment of the beneficial uses of the stream from total aluminum. This is a reasonable assumption because both metals appear to be coming from the same sources and both tend to have elevated concentrations at low pH. The water quality data from Hurricane Creek provide additional support for this approach, since high concentrations of one metal are typically associated with high concentrations of the other. Based on all water quality data for Hurricane Creek for which both total aluminum and pH were measured, the concentrations of total aluminum were consistently within the range of total aluminum concentrations for the Bear Creek reference stream as long as pH was greater than 6 standard units.

Alabama Administrative Code Rule 335-6-10-.09(5)(e)2 specifies that instream pH should not be less than 6, nor greater than 8.5 standard units. Although Hurricane Creek is not currently listed for pH on Alabama's 303(d) list, the water quality data indicate that some tributaries of Hurricane Creek, especially Blanchet Branch and Weldon Creek, do not meet the pH requirement. The use of a different target for iron at low pH should not be interpreted to mean that an instream pH less than 6 is acceptable. Rather, two separate targets are used because the average dissolved component of total recoverable iron is lower at neutral pHs than at acidic ones. The use of dual targets also acknowledges that, in this region, streams may contain levels of <u>total</u> recoverable iron that occasionally exceed the National Recommended criterion and still have healthy aquatic life. In practice, the stream pH should not violate the State criterion of 6 to 8.5 standard units. In fact, the lower allowable concentration for iron at low pH serves as a more stringent target and results in higher required percent reductions. Although metals concentrations are typically higher at acidic pHs, it is even more desirable to maintain lower metals concentrations at low pH. Otherwise, when the stream pH recovers due to dilution or the addition of alkaline material, the metals will precipitate, forming particulates that can obstruct fish gills and otherwise adversely impact aquatic habitat as they settle to the streambed. Precipitating metals may also form unsightly coatings of oxyhydroxide minerals on the rocks, gravel, and sand of the streambed. These precipitates may act as an instream stock of pollutants that can be transported downstream or be resuspended in the water column if stream chemistry changes.

Maintaining the instream pH within the range of 6 to 8.5 standard units in all parts of the watershed is an important factor in keeping metals concentrations low, but the real goal in remediating acid mine drainage is to reduce the total acidity of the affected water. Acidity can be thought of as the amount of a base required to raise the pH of the solution to a specific level. The pH, which denotes the negative logarithm of the hydrogen ion (H^+) concentration, is an accurate measure of the total acidity of mine drainage only when dissolved metals concentrations are low (i.e. the solution is very dilute). In reality, pH is only one component of the total acidity. The metal ions in mine drainage can undergo hydrolosis reactions that release hydrogen ions if the solution is neutralized or oxidized. These metals ions represent a significant source of "latent" or "stored" acidity that has the potential to release additional H^+ ions, re-lowering the pH. In fact, depending on the dissolved ion concentrations, pH acidity may comprise only a small fraction of the total acidity. Total acidity may be measured in a laboratory, or it may be estimated from known pH and dissolved metals concentrations as:

$$\text{Acidity} = 50[((3*C_{Fe3+} + 2*C_{Fe2+})/55.85)) + (3C_{Al3+}/26.98) + (2*C_{Mn2+}/54.94) + 10^{(3-pH)}]$$

where C represents the concentration (mg/L) of each ion (Rose and Cravotta 1998 and U.S. EPA 2000). Because pH and dissolved metal ions- particularly iron, aluminum and manganese- all contribute to total acidity, they must all be controlled to limit acidity.

Alkalinity is a measure of the amount of acid required to lower the pH of a solution to a given value. Alkalinity is desirable in streams because it buffers against changes in pH. In mine waters, most alkalinity is derived from dissolved carbonates. There exist a variety of bases that could contribute to alkalinity, and a variety of acids that could contribute to acidity, so both quantities are standardized to the equivalent units of calcium carbonate ($CaCO_3$). (Although hardness, alkalinity and acidity are all expressed in units of mg/L $CaCO_3$, each specifies a different chemical quantity and the terms should not be confused). Since metal ions can buffer against changes in pH, and since pH is on log scale, a unit change in pH is not proportional to a unit change in acidity or alkalinity. Net alkalinity, the difference between alkalinity and acidity, is considered to be the single best indicator of the influence of mine drainage (Rose and Cravotta 1998). It is a useful characteristic because it serves as an estimate of the amount of alkaline material that needs to be added to bring the water to a (positive) net alkaline state. A positive net alkalinity means that the stream has enough buffering capacity to prevent fluctuations in pH. Net alkaline waters are generally in compliance with pH requirements.

3.3 Applicable Water Quality Standard for Turbidity

Alabama Administrative Code Rule 335-6-10-.09(5)(e)9 describes the numeric criterion for turbidity in Fish and Wildlife streams:

> "There shall be no turbidity other than of natural origin that will cause substantial visible contrast with the natural appearance of the waters or interfere with any beneficial uses which they serve. Furthermore, in no case shall the turbidity exceed 50 NTU above background. Background will be interpreted as the natural condition of the receiving water without the influence of man-made or man-induced causes. Turbidity caused by natural runoff will be included in establishing background levels."

3.4 Identification of Numeric Target for Turbidity

Turbidity is a measure of water clarity. Turbidity is often caused by sediment suspended in the water, but it may also come from a variety of other sources such as algae, microorganisms, or organic matter. Turbidity may reflect the presence of bottom-feeders as they stir up streambed materials. Turbidity measurements may even be affected by the color of the water. Turbidity is of concern because high levels may increase water temperatures and lower photosynthesis, decreasing levels of dissolved oxygen. Suspended particles may also clog fish gills and smother fish eggs if they settle to the streambed.

Because turbidity is not a concentration or load of one particular pollutant, and because the available data show poor relationships between turbidity and total suspended solids in the water, the turbidity TMDL will use an *other appropriate measure* (40 CFR §

130.7) and be expressed in Nepelometric Turbidity Units (NTU). Both point and non-point sources should meet this standard.

ADEM has recently begun measuring turbidity in Bear Creek. However, the data are not yet sufficient to establish background turbidity levels under different flow regimes or other stream conditions. Sediment-related turbidity might be expected to be temporarily higher during and immediately after a rain event. To be conservative, background turbidity will be assumed to be 10.8 NTU, which is equal to the lowest measured turbidity on Bear Creek. Since even the natural turbidity due to sediment would likely be highest during rain events, this assumption would be especially conservative during the expected critical conditions.

3.5 Applicable Water Quality Standard for Pathogens

In Alabama, fecal coliform bacteria are used as the indicator for pathogens. Fecal coliform will be referred to throughout the rest of this report to represent the pathogen impairment. Alabama Administrative Code Rule 335-6-10-.09(5)(e)7.(i) provides numeric water quality criteria for fecal coliform bacteria in Fish and Wildlife streams:

> "Bacteria of the fecal coliform group shall not exceed a geometric mean of 1,000/100 ml; nor exceed a maximum of 2,000/100 ml in any sample. The geometric mean shall be calculated from no less than five samples collected at a given station over a 30-day period at intervals not less than 24 hours."

To protect usage of the water for incidental water contact and recreation during the months of June through September, the following numeric water quality criteria are provided in Alabama's Administrative Code Rule 335-6-10-.09(5)(e)7.(ii):

> "For incidental water contact and recreation during June through September, the bacterial quality of the water is acceptable when a sanitary survey by the controlling health authorities reveals no source of dangerous pollution and when the geometric mean fecal coliform organism density does not exceed 100/100 ml in coastal waters and 200/100 ml in other waters. The geometric mean shall be calculated from no less than five samples collected at a given station over a 30-day period at intervals not less than 24 hours."

3.6 Identification of Numeric Target for Pathogens

Although the geometric mean criteria are the most stringent, and would therefore be the criteria EPA would preferentially use to develop pathogen TMDLs, the fecal coliform data for Hurricane Creek are not sufficient to evaluate the geometric means. In general, only one sample was collected at a given location within any month. Therefore, the instantaneous criterion of 2,000 organisms per 100 ml will be used as the target.

4.0 Source Assessment

A TMDL evaluation examines the known potential sources of the pollutant in the watershed, including an estimate of the amount of pollutant loading contributed by point sources, nonpoint sources, and background levels. Under the Clean Water Act, sources are broadly classified as point or nonpoint sources. Under 40 CFR § 122.2, a point source is defined as any discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. The NPDES program regulates point source discharges. These discharges can be described by two broad categories: 1) NPDES regulated municipal and industrial wastewater treatment facilities; and 2) NPDES regulated stormwater industrial activities and Municipal Separate Storm Sewer System (MS4) discharges. For the purpose of these TMDLs, any facilities under the National Pollutant Discharge Elimination System (NPDES) Program are considered point sources assigned a waste load allocation (WLA). Nonpoint sources are diffuse sources that cannot be identified as entering the waterbody at a single location. These sources generally involve land activities that contribute pollutants to streams during rainfall runoff events. For the purpose of these TMDLs, nonpoint sources are all sources that are not regulated by the NPDES program. The load allocation (LA) provides for these nonpoint sources. Due to the relatively simple and empirical nature of the analysis method, this source assessment is provided as a qualitative characterization of the potential pollutant sources in the Hurricane Creek watershed.

4.1 Metals

Geologically, the Hurricane Creek watershed is composed primarily of clays, sands and limestones of the Tuscaloosa Group. The rest of the watershed is composed of the Upper Pottsville Formation of the Pennsylvanian age. This level of the Pottsville Formation is composed of sandstones, shales (mudstones) and large discontinuous coal beds. The area of the Hurricane Creek watershed covered by the Pottsville Formation is part of the Warrior Coal Field.

There is a long history of surface and deep mining activities in the Hurricane Creek watershed (U.S. EPA. 2003). Based on the identification of a number of abandoned mining sites in the Hurricane Creek watershed, abandoned mine lands (AML) represent a critical nonpoint source (Figure 4). Abandoned mines can contribute significant amounts of acid mine drainage (AMD), which causes low pH and high metals concentrations in surface and subsurface water in areas where mining activities are or once were present. The information regarding AML sites in the Hurricane Creek watershed, presented in Table 5, was provided by the Birmingham Office of Surface Mining Reclamation and Enforcement.

Acid mine drainage is formed when surface mining activities expose spoil material containing iron disulfide minerals like pyrite. Exposure to oxygen and water creates an oxidizing environment that destabilizes minerals, accelerating weathering processes and producing sulfuric acid and dissolved iron. The series of chemical reactions involved in the weathering of iron disulfide minerals can release quantities of acidity and metals. The rates and completeness of these reactions are bacterially-mediated. In addition, sulfides of copper and arsenic can undergo similar geochemical reactions resulting in the contribution of toxic metal ions into mine wastewater. Depending on geologic factors, the metals found in mining waste may include significant concentrations of trace metals (Lee et al. 2002).

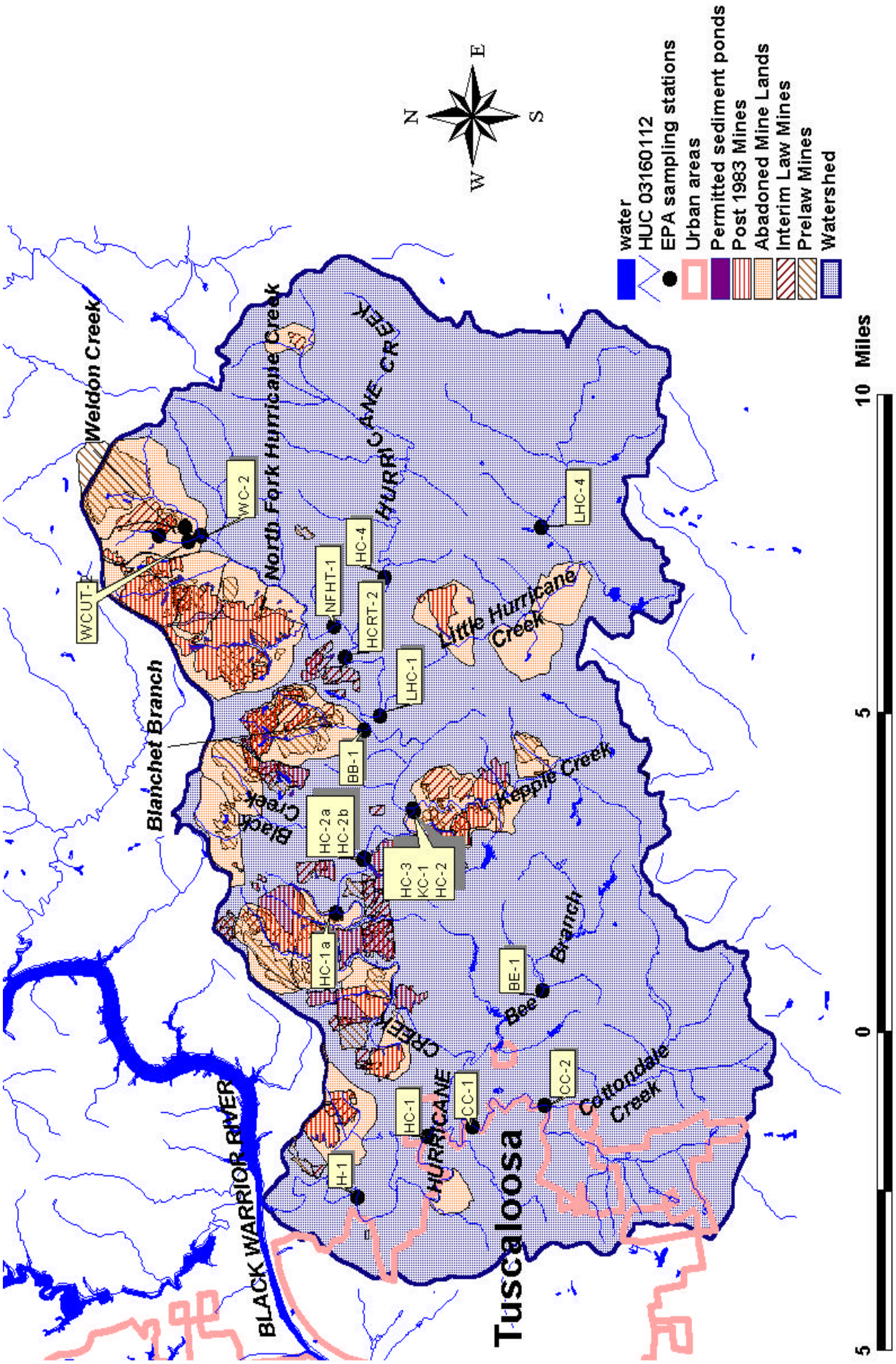


Figure 4. Abandoned, Post 1983, Interim Law, Prelaw Mines in the Hurricane Creek Watershed.
Data Source: Alabama Surface Mining Commission, 2003

Table 5. Abandoned Mine Areas in the Hurricane Creek Watershed.

Problem Area Number	Problem Area Name	Reclaimed / Unreclaimed
AL0009	LAKE WILDWOOD	R/U
AL0012	KLONDIKE, EAST	U
AL0013	FLEETWOOD	R
AL0014	CAMP CHERRY AUSTIN	R/U
AL0026	KLONDIKE, WEST	R/U
AL0029	HOWTON, SOUTH	R/U
AL0031	BIG HURRICANE CHURCH	U
AL0035	BROOKWOOD, SOUTHEAST	U
AL0043	NORTH ALABAMA JUNCTION, EAST	U
AL0051	VANCE, NORTH	U
AL0172	CEDAR COVE	R/U
AL0173	PETERSON, WEST	U
AL0174	PETERSON, SOUTH	U
AL0476	TUSCALOOSA, EAST	R
AL0483	BLACK WARRIOR	R
AL0485	QUARRY LANDING	R
AL0590	HOLT, SOUTH	R
AL0607	DUDLEY	R
AL0619	CEDAR COVE, WEST	U
AL0620	CEDAR COVE, NORTH	U
AL0711	NORTH FORK CREEK	U
AL0712	BLACK CREEK	U
AL0719	ROCKY BRANCH	U
AL0720	FLEETWOOD, NORTH	R/U
AL0721	PETERSON	U
AL0722	HOLT	U
AL0841	ALCO	R

Point source discharges from deep, surface, and other mines may contain high concentrations of metals. Consequently, coal-mining activities are usually issued discharge permits for total iron, total manganese, total suspended solids, and pH. The discharge limits in Table 6 are generally applicable to coal mining operations in Alabama, but under certain conditions, he allowable limits may be significantly higher. For example, if neutralization and sedimentation are not sufficient to meet the limits for manganese, then pH is allowed to be as high as 10.5 standard units. Also, surface water runoff may be exempt from some or all of the limitations for up to 24 hours after a significant precipitation event, as long as there is evidence that the increase in the discharge volume was related to that event. The exact nature of the exemptions depends on the size of the rainstorm. The rationale behind these exemptions is that the increased stream flow will have a diluting effect on the effluent, it would be technically infeasible to treat runoff from major storm events with current technology, and that the increased discharge is temporary. It is important to note that these exemptions apply only to the effluent; water quality standards must be maintained in the stream.

Table 6. Generally Applicable Coal Mining Permit Discharge Limitations in Alabama

Parameter	units	Daily Minimum	Daily Average	Daily Maximum
Iron, Total	mg/L	3.0	N/A	6
Manganese, Total	mg/L	N/A	2.0	4.0
Total Suspended Solids	mg/L	N/A	35.0	70.0
pH	su	6.0	N/A	9
Flow [1]	mgd	monitor	monitor	monitor

1. Flow is determined at the time of collection.

There are a total of 7 active and about 50 closed or expired mining discharge permits in the Hurricane Creek watershed. The active mining operations are located mainly in the northern portion of the watershed, especially in North Fork Hurricane Creek and its tributaries, with some facilities located along Hurricane Creek and Little Hurricane Creek. A list of active mining permits in the Hurricane Creek watershed is in Table 7.

Table 7. Active Mining Permits in the Hurricane Creek Watershed

Permit #	Name	Receiving Waters	LAT	LON	Permit Issued	Permit expires	SIC[1]
AL0041688	Drummand Company E Brookwood	Weldon Creek, UT Weldon Creek	33.25944	-87.27083	30-Jul-98	31-Jul-03	1221
AL0045403	Basin Coal Hurricane Cr. Mine	UT Hurricane Creek	33.23333	-87.30833	29-Mar-99	31-Mar-04	1221
AL0061832	Drummand Co. Kellerman Mine 2	UT Weldon Cr., Jimmy Cr., UT North Fork	33.26472	-87.27972	30-Apr-01	30-Apr-06	1221
AL0067245	AL Pigments Co. Hematite Mine	UT Little Hurricane Cr.	33.16667	-87.26528	30-Apr-01	30-Apr-06	1422
AL0071358	Fleetwood Mine Black Warrior	Hurricane Creek, UT to Hurricane Creek	33.22194	-87.41472	14-Feb-03	31-Jan-08	1221
AL0074012	Tuscaloosa Resources Panther 3	North Fork Hurricane Creek and UT	33.24583	-87.29333	17-Dec-01	30-Nov-06	1221
AL0074349	East Brookwood Mine Tuscaloosa	Weldon Creek, UT to Weldon Creek	33.25917	-87.27111	11-Sep-02	31-Aug-07	1221

1. SIC stands for "Standard Industrial Classification". It is a four-digit code for the principal activity causing discharge at the facility. SIC 1221 signifies bituminous coal and lignite surface mining. SIC 1422 represents crushed and broken limestone operations.

Other, non-mining sources of metals may include stormwater runoff that carries sediment from dirt roads, construction sites, and other unvegetated areas. Industrial stormwater discharges are also potential sources of metals. Municipal Separate Storm Sewer Systems (MS4s) may discharge metals to waterbodies in response to storm events. During rain events, metals originating from automobiles and other urban sources are transported to the stream through road drainage systems, curb and gutter systems, ditches and storm drains. MS4 areas serving populations greater than 50,000 people have been required to obtain an NPDES storm water permit under Phase II of the NPDES Storm Water Program. The city of Tuscaloosa is included in an MS4 permit (#ALR040021). Potions of lower Hurricane Creek, including the Cottondale Creek tributary, is within the area covered by this MS4 permit (Figure 1). In addition, parts of the county of Tuscaloosa have submitted an application for an MS4 permit, which may be issued as early as November 2003. The MS4 permit requires quarterly collection and analysis of water quality samples at selected locations and times.

4.2 Turbidity

The mainstem of Hurricane Creek was listed for turbidity on Alabama's 1998, 2000, and 2002 303(d) lists. The turbidity impairments have been attributed by ADEM to mining and land development. Suspended sediment can be a major cause of high turbidity, especially during and soon after rainstorms. As such, potential nonpoint sources include any landuse that increases soil erosion during rain events. These landuses include abandoned mines, residential development or other construction activities, dirt roads, silvicultural operations, row crops, and other bare lands. Development and urbanization of the watershed, especially in the Cottondale Creek area, may also affect turbidity. Rainfall that would normally infiltrate into the soil and be at least partly absorbed by vegetation may run over impervious surfaces, either directly to the stream or via storm sewers, picking up contaminants as it washes over the roads and parking lots. Hurricane Creek is naturally somewhat flashy due to its hilly topography and the heavy rainstorms typical of the southeast, but urban runoff may exacerbate this characteristic by delivering rainfall in higher amounts and in much shorter periods of time than natural infiltration would allow. Sudden increases in streamflow can cause streams to erode their banks more, increasing the sediment loads being transported. The impact of sediment runoff originating from any of the land uses listed above can be mitigated or even eliminated through the use of appropriate Best Management Practices (BMPs) and stormwater management practices. Sediment loads from past land activities that remain stored in the stream, may continue to contribute suspended sediment to the water, causing increased turbidity.

There is one facility that has an active NPDES permit to discharge total suspended solids (TSS) to a tributary of Little Hurricane Creek (NPDES#: AL0057517). The permit limit specifies an average weekly maximum of 135 mg/L, and an average monthly maximum of 90 mg/L. However, the contribution of TSS from this source would be very small compared to that from non-point sources. Turbidity may also be affected by wet weather discharge from permitted mining sources.

While sediment and other suspended solids may be a source of turbidity, the instream water quality data show a poor correlation between turbidity and TSS. It is possible that the data do not capture a stronger association between turbidity and sedimentation because the samples were not collected soon enough after rainstorms. Because turbidity may also result from other substances such as algae, microorganisms, or organic matter, another possibility is that the occasionally high turbidity values measured in Hurricane Creek were caused by different sources.

4.3 Pathogens

Hurricane Creek and Little Hurricane Creek were listed for pathogens on Alabama's 1998, 2000, and 2002 303d lists. The pathogen impairments have been attributed by the state to land development.

Nonpoint sources of fecal coliform bacteria are diffuse sources that cannot be identified as entering the waterbody at a single location. These sources generally involve land activities that contribute fecal coliform bacteria to streams during rainfall runoff events. Typical nonpoint sources of fecal coliform bacteria that may be present in the Hurricane Creek watershed include runoff from agricultural lands, leaking septic systems or sewers, urban runoff, and wildlife and other animals with access to the streams.

Municipal Separate Storm Sewer Systems (MS4s) may also discharge bacteria to waterbodies in response to storms. During rain events, fecal coliform originating from domestic pets, wildlife, and other urban sources is transported to the stream through road drainage systems, curb and gutter systems, ditches and storm drains. The MS4 permit requires quarterly collection of water quality samples at selected locations and times. Samples are analyzed for conventional pollutants, including fecal coliform. The MS4 permit does not have fecal coliform concentration limits. Urban runoff may represent a significant source of pathogens in the developed parts of Tuscaloosa that encroach into the watershed boundaries.

There is one minor domestic waste point source permitted to discharge fecal coliform to a tributary of Little Hurricane Creek (NPDES #:AL0057517). The permit limits specify that the maximum concentration of fecal coliform is not to exceed a geometric mean of 200 counts per 100 ml during the summer months, a geometric mean of 1000 counts per 100 ml during non-summer months, nor 2000 counts per 100 ml in any sample during all times of the year. These “end-of-pipe” permit limits are consistent with the water quality standards in Alabama. However, the Discharge Monitoring Reports show periodic violations of these limits, so it is important that ADEM enforce compliance with the permit.

A high percentage of the residential developments outside of the Tuscaloosa city limits rely on septic systems for wastewater treatment (Tuscaloosa Environmental Health Department 2001). Onsite septic systems have the potential to deliver fecal coliform bacteria loads to surface waters due to system failure and malfunction. ADEM’s CA database estimates an approximate 10 percent failure rate for septic systems in the Hurricane Creek watershed. Due to the abundance of septic systems in the unincorporated parts of the watershed, failing septic systems may represent a critical nonpoint source.

5.0 Water Quality Data Assessment

The data used to determine TMDLs for listed parameters comes from a variety of studies that have been conducted within the last ten years. These sources include ADEM data from four dates in June and August 1996, and from ten dates between June 2000 and October 2002. Water quality measurements made by the Alabama Rivers Alliance (ARA) in May through August 2000 were also used where applicable (see Wentzel and Duncan 2001). In addition, data from the water quality sampling that EPA conducted throughout the Hurricane Creek watershed in July and August 2002 are incorporated in the TMDL assessment. The results of the EPA study are discussed in detail in the Hurricane Creek Watershed Water Quality Sampling Report (U.S. EPA. 2003). Some of the water quality data did not have accompanying flow measurements, so missing flows were estimated using the drainage area ratio method. The drainage area ratio method uses a flow value measured on the date of interest at a site of known drainage area (preferably one within the same watershed) to estimate the unknown flow at a different site of known drainage area. A proportional flow is estimated by multiplying the measured flow by the ratio of the drainage areas.

The data show that the most consistently high concentrations of metals occur in the Blanchet Branch and Weldon Creek watersheds, both of which drain mined areas. In particular, the low flows in these tributaries are insufficient to dilute high metals concentrations, which are able to stay in the water column due to low pHs. Estimates of net alkalinity indicate that the net alkalinity of the upper reaches of Blanchet Branch needs to be increased by approximately 100 mg/L $CaCO_3$ to achieve a positive net alkalinity, while the net alkalinity in the upper reaches of Weldon Creek would require an increase of as much as 400 mg/L $CaCO_3$. This could be accomplished through chemical neutralization of mine drainage by the addition of a basic substance such as limestone, hydrated lime, caustic soda, soda ash, or ammonia. The lower reaches of both waters demonstrate the value of quantifying net alkalinity. Lower Blanchet Branch and North Fork Hurricane Creek (which is downstream of Weldon Creek), both experience a recovery in pH to near neutral conditions. However, metals introduced upstream may take a while to come out of solution, and the metals concentrations are still high enough in North Fork Hurricane Creek and lower Blanchet Branch that the net alkalinities are sometimes negative (meaning there is more acidity than available alkalinity to neutralize it). Beyond having a positive net alkalinity, it would be reasonable to target restoration of the net alkalinity in the Hurricane Creek watershed to the average value for a reference stream. The acidity of Bear Creek, the candidate reference stream for the Shale Hills ecoregion, as calculated from measurements of dissolved metals, is low (averaging about 1.5 mg/L $CaCO_3$). The average net alkalinity in Bear Creek is about 15 mg/L $CaCO_3$.

Based on all of the available arsenic data, arsenic does not require a TMDL. Arsenic (As) was below detection for every station sampled by the EPA in August 2002. Arsenic was also below detection in every sample from the ten collections ADEM conducted between June 2000 and October 2002 (a total of 54 samples), with the exception of one sample taken from the North Fork Hurricane Creek in October 2002. However, that detected level was below the acute and chronic criteria. Arsenic was above detection at two sites on Little Hurricane Creek, which were sampled by ADEM during August 1996, but those values were also well below the acute and chronic standards. Since all sections of Hurricane Creek, including the listed waterbody of Little Hurricane Creek, appear to be meeting the State's water quality standards for arsenic, no reductions are needed.

Trivalent chromium was above detection in four samples collected by ADEM for Little Hurricane Creek on August 27 and 28, 1996. All four values were above their respective hardness-based acute (and chronic) criteria. There were also four excursions elsewhere on the mainstem and North Fork Hurricane Creek on those same dates. However, chromium values were below detection for all of the EPA 2002 data, and for all of the ADEM 2000-2002 data. Because the only measured exceedances of chromium occurred on two consecutive days in August 1996, it is likely that they are related to a specific land clearing event, and do not accurately represent current conditions in the watershed. At this time, no TMDL or load reductions for trivalent chromium are needed.

About half of the calculated copper exceedances occurred during the four sampling dates in the summer of 1996. Turbidity was very high then, suggesting that the metal may have been associated with sediment, organic colloids, or some other suspended particulates. In fact, all but two of the turbidity exceedances were measured on the four sampling dates in the summer of 1996. More recent copper excursions occurred at four sites in October 2002 (one on Little Hurricane Creek and three on the mainstem). Site HCRT-1, on the mainstem upstream of North Fork Hurricane Creek (near EPA station HC-4 in Figure 1), is the only sampling station for which copper has exceeded the hardness-based criteria more than once. The close proximity of this site to the bridge for George Newell Road, and its distance from any active or abandoned mines, suggests that the source is road runoff.

Although Cottondale Creek is not an explicitly listed segment on the State's 303(d) list, both stations sampled by EPA in that subwatershed indicated biological impairment based on habitat scores and samplings of the benthic macroinvertebrate communities. During a visit by EPA to the watershed in September 2003, the water was obviously turbid due to sediment loads in the stream, even though it hadn't rained in days. Water quality issues in Cottondale Creek may influence the overall biological health of stations HC-1 and H-1, which are downstream of the confluence with Cottondale Creek. Stations HC-1 and H-1 were rated as impaired by EPA in August 2000 based on an assessment of benthic macroinvertebrate communities. Although Weldon Creek and Blanchet Branch were not directly assessed, their low pH and high metals concentrations indicate that such impairment exists. North Fork Hurricane Creek, which is downstream of Weldon Creek, was also rated as biologically impaired. Additional flow and dilution within Hurricane Creek appear to mitigate the effects of low pH and high metals concentrations observed in the tributaries. The biology for stations located on the mainstem (excepting the stations downstream of Cottondale) was rated to be good overall.

The highest fecal coliform concentrations occur during both wet and dry weather, suggesting that pathogens may come from a variety of sources. Although there are only three measured exceedances of the instantaneous standard of 2000 counts/100 mL, the fact that there are several fecal coliform data above the 200 counts/100 mL standard is noteworthy. It would be beneficial to collect additional data sufficient to calculate geometric means in order to determine whether the concentrations are chronically that high during the summer months.

6.0 Total Maximum Daily Load

A Total Maximum Daily Load (TMDL) establishes the total pollutant load a waterbody can assimilate and still achieve water quality standards. The components of a TMDL include a wasteload allocation (WLA) for point sources, a load allocation (LA) for nonpoint sources (including natural background), and a margin of safety (MOS), either implicitly or explicitly, to account for uncertainty in the analysis. Conceptually, a TMDL is defined by the equation:

$$TMDL = \sum WLA + \sum LA + MOS$$

6.1 TMDLs for Metals

As previously discussed, the percent reductions for total iron are also being used to quantify the percent reductions for total aluminum. It is reasonable to do this because both metals appear to be coming from the same sources and both tend to have much higher concentrations, and higher dissolved fractions, at low pH. The water quality data from Hurricane Creek provide additional support for this approach, since elevated concentrations of one metal are typically associated with elevated concentrations of the other. The required percent reductions for iron are high, and it is expected that the same reductions necessary to address the total iron being contributed by acid mine drainage and nonpoint source runoff will sufficiently reduce the loadings of aluminum to protect beneficial uses of the stream. Based on all water quality data for Hurricane Creek for which both total aluminum and pH were measured, the concentrations of total aluminum were consistently within the range of total aluminum concentrations for the Bear Creek reference stream as long as pH was greater than 6 standard units (Figure 5). Since trace metals tend to precipitate out with oxides, reductions in iron and aluminum concentrations should even lower the concentrations of other listed and nonlisted trace metals (Lee et al. 2002).

The metals TMDLs are expressed as the percent reduction of the existing concentrations required to meet the target concentrations. For total iron, the target used is 3.45 mg/L if pH>6, or 1.12 mg/L if pH<6. For total copper, the target was based on the hardness of the sample (Table 2). This approach is consistent with federal regulations (40 CFR § 130.2(i)), which state that TMDLs can be expressed in terms of mass per time, toxicity, or *other appropriate measure*. The TMDLs are calculated from instream concentrations, using the average of any values greater than the applicable criterion. Any measurements made on tributaries to a listed segment are included in the calculations for that segment. Data from Weldon Creek are included in the calculations for North Fork Hurricane Creek, and data from Blanchet Branch, Cottondale Creek, Kepple Creek and Bee Branch were included with the mainstem of Hurricane Creek. **Most of the required reduction for Hurricane Creek, and all of the required reduction for North Fork Hurricane Creek, were due to Blanchet Branch and Weldon Creek, respectively**.

Figure 5. pH and Total Aluminum Concentrations in Hurricane Creek and Bear Creek

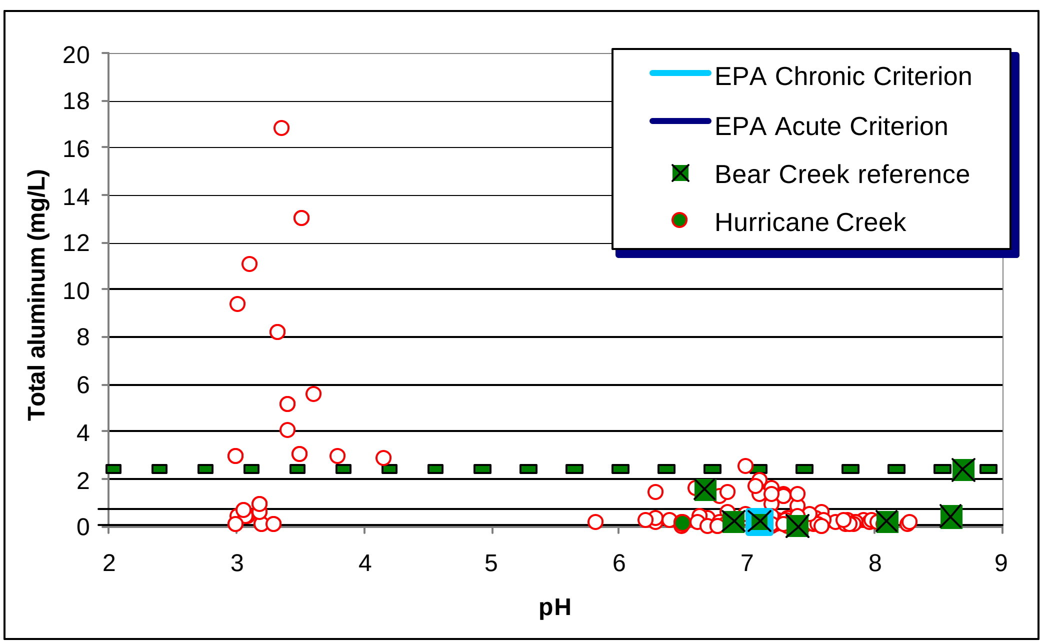


Table 8. TMDL Allocations for Metals

waterbody	Waste Load Allocation					Load Allocation			Margin of Safety	TMDL	
	MS4		FACILITY[1]								
	pH s.u.	Fe/Al P.R.	pH s.u.	Fe[2] mg/l	Cu[3] mg/L	pH s.u.	Fe/Al P.R.	Cu P.R.		Fe/Al P.R.	Cu P.R.
Hurricane Creek	6-8.5	75%	6-8.5	3.45	NA	6-8.5	75%	NA	implicit	75%	NA
Little Hurricane Creek	6-8.5	NA	6-8.5	3.45	0.004	6-8.5	86%	33%	implicit	86%	33%
North Fork Hurricane Creek	6-8.5	NA	6-8.5	3.45	NA	6-8.5	98%	NA	implicit	98%	NA

1. The Facility Waste Load Allocation (WLA) applies to individual NPDES permitted facilities, including non-MS4 regulated stormwater dischargers. For continuous dischargers, the WLA shall apply to a four-day average concentration. For wet weather dischargers, the WLA shall apply to an event mean concentration.
2. The WLA for aluminum is a narrative that assumes meeting the WLA for iron and pH will inherently protect for aluminum.
3. The WLA for copper is equivalent to the hardness-based chronic criterion. The number in the table is calculated from the lowest measured hardness for any station on Little Hurricane Creek (27 mg/L $CaCO_3$).
4. Abbreviations: Fe = total iron; Al = total aluminum; Cu = total copper; s.u.= standard units; P.R. = percent reduction.

6.1.1 Waste Load Allocation (WLA)

The WLA accounts for point source loads regulated under the NPDES program. There are two active NPDES permitted discharges of metals in Hurricane Creek or its tributaries, one active discharge in the Little Hurricane Creek watershed, and four in North Fork Hurricane Creek (or Weldon Creek upstream of North Fork Hurricane Creek (Table 10). The WLA for discharge of iron from active mines is an "end of pipe" criterion that would require the event mean concentrations of the discharge to not exceed 3.45 mg/L, and the pH of to be maintained between 6-8.5. The WLA for aluminum is a narrative that assumes achieving the same percent reduction as iron, and meeting the pH requirement, will inherently protect against impairment from aluminum. The WLA for copper is an "end of pipe" criterion equivalent to the hardness-based criterion for chronic concentrations of total copper. Applying "end of pipe" criteria is a conservative allocation that assumes no instream dilution of the metal. Permits that limit that discharge to the water quality standard will should not cause or contribute to any impairment in that waterbody.

Since lower Hurricane Creek, including the Cottondale Creek tributary, is partly within the Tuscaloosa MS4 permit area, its WLA is broken out into separate subcategories for wastewater discharges and stormwater discharges regulated under the NPDES program. It is important to note that the WLA for stormwater (MS4) and the WLA for other point sources (Facility) are expressed in different terms. The WLA for NPDES MS4 stormwater is based on the percent reduction and is accounted for within the LA, while the WLA for other point sources is expressed as the target concentration for facility permits.

Although the aggregate wasteload allocation for storm water discharges is expressed in numeric form as a percent reduction, based on the information available today, it is infeasible to calculate numeric WLAs for individual storm water outfalls because discharges from these sources can be highly intermittent, are usually characterized by very high flows occurring over relatively short time intervals, and carry a variety of pollutants whose nature and extent varies according to geography and local land use. For example, municipal sources such as those covered by this TMDL often include numerous individual outfalls spread over large areas. Water quality impacts, in turn, also depend on a wide range of factors, including the magnitude and duration of rainfall events, the time period between events, soil conditions, fraction of land that is impervious to rainfall, other land use activities, and the ratio of storm water discharge to receiving water flow. This TMDL assumes for the reasons stated above that it also will be infeasible to calculate numeric water quality-based effluent limitations for metals for storm water discharges. Therefore, in the absence of information presented to the permitting authority showing otherwise, this TMDL assumes that water quality-based effluent limitations for storm water sources of metals derived from this TMDL can be expressed in narrative form (e.g., as best management practices), provided that (1) the permitting authority explains in the permit fact sheet the reasons it expects the chosen BMPs to achieve the aggregate wasteload allocation for these storm water discharges; and (2) the state will perform ambient water quality monitoring for metals for the purpose of determining whether the BMPs in fact are achieving such aggregate wasteload allocation.

6.1.2 Load Allocation (LA)

Other nonpoint sources outside of the MS4-permitted area are contributing to metals violations in the Hurricane Creek watershed. The load allocations for these sources are expressed as the percent reductions required for the average of the observed instream exceedances to meet their target concentrations.

6.1.3 Margin of Safety (MOS)

A Margin of Safety (MOS) is a required component of a TMDL that accounts for the uncertainty in the relationship between the pollutant loads and the quality of the receiving waterbody. An MOS can be incorporated explicitly or implicitly or both. An explicit margin of safety would be provided by reserving a specific allocation. An implicit MOS is incorporated into conservative assumptions used to develop the TMDL.

An MOS is incorporated into these TMDLs by using instream measurements, including samples from tributaries to the listed segments, to characterize the existing conditions, by using a lower target at low pH, and by setting the existing load equal to the highest measured concentrations. An additional MOS is reserved from the WLA by applying end-of-pipe criteria to permitted discharges, which assumes no instream dilution. The required percent reductions are high enough that also reserving an explicit MOS would have little effect.

6.1.4 Critical Conditions and Seasonal Variation

A TMDL must take into account the critical conditions under which instream pollutant concentrations are expected to be highest. For example, changes in flow can have contradictory effects depending on the source of pollutants. If rainwater carries metals to the stream in runoff, then their concentrations may be highest during high flow conditions. Conversely, if high flows dilute the pollutants or if there are significant stores of pollutants already in the stream, then water quality problems may be worse at lower flow due to the lack of dilution.

The critical conditions for metals appear to be under low flows, when pH is low and the concentrations are exacerbated due to the lack of dilution. Since flows tend to be lowest in summertime, and most of the data was collected during the summer months (and in drought years), and since data from low-flow tributaries was included in the calculations, it is expected that the critical conditions for iron and aluminum are adequately represented in the TMDLs. By basing loads and reductions on this period, the standards should be met at other times of the year.

6.2 TMDL for Turbidity

TMDLs are frequently expressed in mass loads per time. Because turbidity is not a load, but rather an indicator of the clarity of the water, and because the data show a poor relationship between turbidity and flow, and between turbidity and total suspended solids in the water, this analysis will use an *other appropriate measure* (40 CFR § 130.2(i)) and express the TMDL in Nepelometric Turbidity Units (NTU). The appropriate target was selected as the numeric criterion described in Alabama Water Quality Criteria, which states that turbidity should be no more than 50 NTU above background levels. Both point and non-point sources should meet the standard.

At this time, it is not feasible to establish natural background levels of turbidity under different flow regimes. Depending on the source, turbidity might be expected to be elevated during and immediately after a rain event. To be conservative, background turbidity will be assumed to be equal to the lowest measured turbidity on the Bear Creek reference stream (10.8 NTU). Since even natural turbidity would likely be highest during or immediately after rain events, this assumption should be somewhat more conservative during high flow conditions. The highest turbidity recorded on the mainstem of Hurricane Creek was used to represent existing exceedances. Because this value was qualified as > 90 NTU, the existing turbidity was set to 90 NTUs instead of an average of the exceedances.

Table 9. TMDL Allocation for Turbidity

Waterbody	Waste Load Allocation		Load Allocation[2]	Margin of Safety	TMDL
	MS4 P.R.	Facility[1] NTU	P.R.		P.R.
Hurricane Creek	32%	60.8	32%	implicit	32%

1. The Facility Waste Load Allocation applies to individual NPDES permitted facilities, including non-MS4 regulated stormwater dischargers. The average turbidity associated with the discharge for a storm event shall not exceed this limit.
2. The turbidity levels of all waters originating from non-point sources shall not exceed 60.8 NTU.
3. Abbreviations: P.R. = percent reduction; NTU = Nephelometric Turbidity Units.

6.2.1 Waste Load Allocation (WLA)

NPDES permits for total suspended solids or other substances that may cause turbidity should require measurements to ensure the discharge does not increase turbidity to greater than 60.8 NTUs. Any future permitted discharges should not exceed this water quality criterion.

The WLA is broken out into separate subcategories for wastewater discharges (Facility) and stormwater discharges (MS4) regulated under the NPDES program. The WLA for stormwater is based on the percent reduction and is accounted for within the LA, while the WLA for other point sources is expressed as the target turbidity for facility permits.

Although the aggregate wasteload allocation for storm water discharges is expressed in numeric form as a percent reduction, based on the information available today, it is infeasible to calculate numeric WLAs for individual storm water outfalls because discharges from these sources can be highly intermittent, are usually characterized by very high flows occurring over relatively short time intervals, and carry a variety of pollutants whose nature and extent varies according to geography and local land use. For example, municipal sources such as those covered by this TMDL often include numerous individual outfalls spread over large areas. Water quality impacts, in turn, also depend on a wide range of factors, including the magnitude and duration of rainfall events, the time period between events, soil conditions, fraction of land that is impervious to rainfall, other land use activities, and the ratio of storm water discharge to receiving water flow. This TMDL assumes, for the reasons stated above, that it will also be infeasible to calculate numeric water quality-based effluent limitations for metals for storm water discharges. Therefore, in the absence of information presented to the permitting authority showing otherwise, this TMDL assumes that water quality-based effluent limitations for storm water sources of turbidity derived from this TMDL can be expressed in narrative form (e.g., as best management practices), provided that (1) the permitting authority explains in the permit fact sheet the reasons it expects the chosen BMPs to achieve the aggregate wasteload allocation for these storm water discharges; and (2) the state will perform ambient water quality monitoring for turbidity for the purpose of determining whether the BMPs in fact are achieving such aggregate wasteload allocation.

6.2.2 Load Allocation (LA)

Since non-point sources are probably contributing to turbidity in the stream, the target turbidity is also 60.8 NTU. Although only the main stem of Hurricane Creek is listed for turbidity, this target should also be met in all tributaries to the mainstem. The load allocation is expressed as the percent reduction required for the highest observed instream turbidity to meet the target. The data show that turbidity is usually low throughout the watershed. In fact, the highest turbidities recorded anywhere in watershed were measured by ADEM in Little Hurricane Creek during the summer of 1996. These very high values may be related to land clearing in that watershed around the time of those samplings.

6.2.3 Margin of Safety (MOS)

A MOS is incorporated into the turbidity TMDL by setting the background turbidity to 10.8 NTU, the lowest turbidity recorded on the reference stream, and by using the highest exceedance to characterize the existing conditions.

6.2.4 Critical Conditions and Seasonal Variation

If turbidity exceedances are assumed to be due to sediment then, in theory, the critical condition would be high flows. However, the few exceedances on the mainstem show elevated turbidity at moderate flows and some low turbidities at high flows. As such, critical conditions and seasonal variation are accounted for by requiring that the criteria be met at all flow conditions.

6.3 TMDLs for Pathogens

The TMDLs for pathogens are expressed using fecal coliform bacteria as the indicator. The units specify colonies of fecal coliform organisms per 100 milliliters of water. The instantaneous maximum concentration of 2000 colonies/100 ml is used to evaluate the TMDL. In the original TMDLs, EPA developed a spatial model of the Hurricane Creek watershed, but limited data were available to quantify the sources and calibrate the model. The fecal coliform TMDLs presented in this report are calculated empirically, using the exceedances greater than 2000 colonies/100 ml to represent the existing conditions. The conservative approach is appropriate for small watersheds with limited data. For Hurricane Creek, this means that the TMDL is based on only one sample. For Little Hurricane Creek, averages of the two samples greater than 2000 counts/100 mL were used to determine the TMDL.

Table 10. TMDL Allocations for Pathogens

Waterbody	Waste Load Allocation			Load Allocation	Margin of Safety	TMDL
	MS4	Facility[1] (colonies/100ml)				
	P.R.	Jun. - Sept.	Oct. - May	P.R.		P.R.
Hurricane Creek	67%	200	1000	67%	implicit	67%
Little Hurricane Creek	NA	200	1000	25%	implicit	25%

1. The Facility Waste Load Allocation (WLA) applies to individual NPDES permitted facilities, including non-MS4 regulated stormwater dischargers. The Facility WLAs are "end of pipe" limits of the monthly geometric mean concentration of fecal coliform bacteria. These values are equivalent to the State's Water Quality Standards for fecal coliform bacteria. Future facilities that discharge fecal coliform at or below Water Quality Standards should not cause or contribute to impairment. It is assumed that by meeting the geometric mean 30-day concentration, the instantaneous standard of 2000 colonies/100 ml will not be violated.
2. Abbreviations: P.R. = percent reduction.

6.3.1 Waste Load Allocation (WLA)

The WLA accounts for point source loads regulated under the NPDES program. There is one facility in the Little Hurricane Creek watershed that is currently permitted to discharge a monthly geometric mean fecal coliform concentration of 200 counts per 100 ml in the summer, and a geometric mean of 1000 counts per 100 ml at other times of the year. The permitted daily maximum concentration is 2000 counts/100 ml at all times of the year, which is an "end of pipe" equivalent to Alabama's water quality standards for fecal coliform bacteria. The WLA for the facility reflects these permit limits, since they are already consistent with the State's standards. Any future discharges of fecal coliform at or below water quality standards should not cause or contribute to impairment.

Municipal Separate Storm Sewer Systems (MS4s) may also discharge bacteria to waterbodies in response to storm events. MS4 areas serving populations greater than 50,000 people are required to obtain an NPDES storm water permit under "Phase II" of the NPDES Storm Water Program. The city of Tuscaloosa is included in an MS4 permit that encroaches into the lower Hurricane Creek watershed, including the Cottondale Creek tributary. Because Hurricane Creek is partially covered by an MS4 permit, the WLA is broken out into separate subcategories for wastewater discharges and stormwater discharges regulated under the NPDES program. It is important to note that the WLA for municipal stormwater (MS4) and the WLA for other point sources (facility) are expressed in different terms. The WLA for NPDES stormwater is based on the percent reduction needed for nonpoint sources and is accounted for within the LA, while the WLA for other point sources are expressed as the allowable colonies/100 ml.

Although the aggregate wasteload allocation for storm water discharges is expressed in numeric form as a percent reduction, based on the information available today, it is infeasible to calculate numeric WLAs for individual storm water outfalls because discharges from these sources can be highly intermittent, are usually characterized by very high flows occurring over relatively short time intervals, and carry a variety of pollutants whose nature and extent varies according to geography and local land use. For example, municipal sources such as those covered by this TMDL often include numerous individual outfalls spread over large areas. Water quality impacts, in turn, also depend on a wide range of factors, including the magnitude and duration of rainfall events, the time period between events, soil conditions, fraction of land that is impervious to rainfall, other land use activities, and the ratio of storm water discharge to receiving water flow. This TMDL assumes for the reasons stated above that it also will be infeasible to calculate numeric water quality-based effluent limitations for pathogens for storm water discharges. Therefore, in the absence of information presented to the permitting authority showing otherwise, this TMDL assumes that water quality-based effluent limitations for storm water sources of pathogens derived from this TMDL can be expressed in narrative form (e.g., as best management practices), provided that (1) the permitting authority explains in the permit fact sheet the reasons it expects the chosen BMPs to achieve the aggregate wasteload allocation for these storm water discharges; and (2) the state will perform ambient water quality monitoring for pathogens for the purpose of determining whether the BMPs in fact are achieving such aggregate wasteload allocation.

6.3.2 Load Allocation (LA)

Non-point sources, such as leaking septic systems or runoff from agricultural or developed lands are contributing pathogens to the stream. The load allocations for pathogens are expressed as the percent reductions required for the highest concentrations of fecal coliform bacteria, from all of the available water quality data, to meet the target.

6.3.3 Margin of Safety (MOS)

The TMDLs only use the values that exceed the 2000/100 mL standard to calculate the loads and percent reductions. There is uncertainty that the relatively limited datasets (on Little Hurricane Creek there are 12 total data points; for Hurricane Creek there are 50 data points) are able to capture the full range of fecal concentrations. However, the violations used to estimate the TMDLs are considerably greater than the other fecal coliform concentrations measured in each watershed.

This approach assumes the margin of safety (MOS) is implicit. An implicit MOS is appropriate as the loads are based on instream measurements that account for dilution and do not represent the maximum load that could be transported to the stream from the watershed. It is possible to represent the MOS as an explicit load (for example, reduce the LA component by 10 percent), but the impact on the percent reduction would be negligible.

6.3.4 Critical Conditions and Seasonal Variation

High fecal coliform can occur at both high and low flows. For continuous point sources, the critical period is usually during low flows. For nonpoint sources, the critical condition is usually a dry period followed by a rain event. The two violations on LHC during August 1996 occurred at higher flows. Critical conditions and seasonal variation are represented by using the highest data values to calculate the percent reductions. It is assumed that by meeting the highest reductions from all the available data, the standard should be met at all times of the year.

7.0 Conclusions and Recommendations

These TMDL analyses were performed using the best available data to specify the percent reductions necessary to achieve water quality standards. The intent of meeting the criteria is to support the designated use classification for the watershed. As Fish and Wildlife streams, the primary designated uses of Hurricane Creek waterbodies are fishing, protection of aquatic life, and the propagation of fish and other wildlife. Secondary uses to be protected are incidental water contact and recreation in the summer months.

The watershed has a long history of coal mining that precedes the Surface Mining and Reclamation Act of 1977 (SMCRA). While regulatory oversight of post-1977 mining activities has lead to overall water quality improvements in the watershed (Wentzel and Duncan 2001), resources to treat and restore abandoned mines are limited. Drainage from abandoned mines continues to impair water quality by introducing excess acidity and metals to parts of the watershed. In particular, two low-flow tributaries that drain mined areas, Weldon Creek and Blanchet Branch, experience the highest metals excursions. Additional dilution downstream of these tributaries mitigates the impact of mine drainage, to the extent that good biology is supported on the mainstem (U.S. EPA. 2003). The TMDLs for the listed segments call for high percent reductions, but they were calculated by including data from the tributaries. Remediation efforts focused on those key areas would have the greatest impact, and would also help to protect downstream segments. The reductions for North Fork Hurricane Creek should be addressed by remediation in Weldon Creek, and additional remediation in Blanchet Branch should help maintain the mainstem of Hurricane Creek. In fact, Blanchet Branch may already be showing some mitigation of acid mine drainage due to restablization of mining spoils from development of part of the watershed into a golf course and housing development. For Little Hurricane Creek, controlling runoff from abandoned mines and from roads and construction sites should address the metals impairments.

The most effective method for controlling acid mine drainage is to prevent its formation through water management, the addition of alkaline materials, or controlled placement of pyritic materials to limit exposure to oxygen and water. Where treatment is necessary, techniques to capture contaminated drainage before it enters the stream would help to reduce the quantity of acidity and metals in the water, limit the transport and resuspension of metals downstream, and inhibit the formation of oxide coatings on the streambed, which can degrade aquatic habitat.

Total acidity is the single best measurement for quantifying the overall impact of mine drainage, and for monitoring changes in a stream in response to restoration efforts (Rose and Cravotta 1998). The “Hot Acidity” method (Standard Methods 2310; American Public Health Association 1989), which incorporates contributions to acidity from metallic ions and yields values of the net acidity of a sample, is the recommended method. At the very least, measurements of alkalinity, pH and dissolved iron, aluminum and manganese would allow net alkalinity to be estimated.

Based on the available water quality data, the turbidity impairments in Hurricane Creek do not appear to be severe. Impairment due to turbidity refers to excessive amounts of fine-grained materials being transported in the water column. High turbidity can be caused by sediment in runoff or instream processes. To reduce sediment loads from past and present land disturbing activities such as construction, agriculture, urbanization, and abandoned mine lands, vegetation should be maintained in riparian buffer zones on either bank of the stream. Not only does the vegetation stabilize the soil, but it also helps to slow down runoff, allowing sediment to settle out and moderating the increases in streamflow. Minimization of sediment runoff through appropriate stormwater management practices should help to keep turbidity low and should also result in reductions of metals that may be associated with the sediment.

Development and urbanization, especially in the Cottondale Creek watershed, may also affect water quality. Additional monitoring should be done for siltation and habitat alteration in the Cottondale Creek watershed. Although it is not listed on the State's 303(d) list, the habitat scores for both stations in Cottondale Creek, sampled by EPA in August 2002, indicate biological impairment. Impairment due to siltation implies deposition of fine-grained materials on the channel bed, which can lead to poor oxygenation and make the streambed a poor habitat for aquatic organisms.

Parts of lower Hurricane Creek and Cottondale Creek are within the boundaries covered by the Tuscaloosa MS4 permit (#ALR040021). Additional areas of the county of Tuscaloosa, not already covered by the above permit, have applied for a separate MS4 permit that should be approved as soon as November 2003 (personal communication with Vernetta Palmer, October 14, 2003). MS4 areas are required to obtain an NPDES permit, and to develop a Storm Water Management Program (SWMP) to prevent harmful pollutants from being washed by storm water runoff into the waterbody. The SWMP comprises a comprehensive planning process that involves public participation and intergovernmental coordination to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques, public education and other appropriate measures.

Although there were not many violations of the instantaneous standard for fecal coliform of 2000 counts/100 ml, it is noteworthy that there were several data above the 200 counts/100 ml standard. Collection of additional data sufficient for calculating geometric means (at least 5 samples in one month, collected at the same location not less than 24 hours apart) would allow determination of whether the concentrations exceed that criteria in the summertime. Permit limits for fecal coliform are consistent with the State's water quality standards. However, there have been violations of these limits in the Little Hurricane Creek watershed. Compliance with existing permit requirements will ensure that the waste load contributions will not cause or contribute to any pathogen impairment.

Certain stream characteristics, such as turbidity and metals concentrations, can vary considerably based on the bedrock and soils of the watershed. Measurements of these parameters on a local reference stream that is supporting the same designated uses allows for discrimination between natural and anthropogenic levels. For example, concurrent sampling on Hurricane Creek and a reference stream under different conditions would allow for a more sophisticated interpretation of the "50 NTU above background" standard for turbidity. ADEM has already begun water quality sampling of reference streams in the different ecoregions of the state, including the Shale Hills Ecoregion that drains the majority of Hurricane Creek.

ADEM's rotating watershed monitoring will provide additional water quality data for Hurricane Creek. These TMDLs will be reevaluated during subsequent watershed cycles to assure attainment of water quality standards.

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APPENDIX A

Data and TMDL Calculations

APPENDIX A: Data and TMDL Calculations for Iron/Aluminum

The existing conditions and targets from which the TMDL percent reductions are calculated are the averages of the exceedances, which are shown in bold type. The applicable target concentration for iron is selected based on the pH at the time of sampling. Data from tributaries to each segment are included. The total aluminum values are provided for informational purposes.

Hurricane Creek

Agency	Sample Date	Site	Existing Iron Concentration mg/L	Existing Aluminum Concentration mg/L	pH	Applicable Target Concentration for Iron mg/L
ADEM	6/11/96	H-1	0.292	0.2[B]	7.5	3.45
ADEM	6/11/96	HCRT-4	0.351	0.2[B]	7.8	3.45
ADEM	6/11/96	HCRT-3	0.655	0.544	7.6	3.45
ADEM	6/11/96	HCRT-2	0.528	0.439	7.0	3.45
ADEM	6/11/96	HCRT-1	0.832	0.2[B]	6.9	3.45
ADEM	6/12/96	H-1	0.372	0.2[B]	7.2	3.45
ADEM	6/12/96	HCRT-4	0.428	0.2[B]	7.4	3.45
ADEM	6/12/96	HCRT-3	0.601	0.328	7.0	3.45
ADEM	6/12/96	HCRT-2	0.724	0.817	7.4	3.45
ADEM	6/12/96	HCRT-1	0.877	0.2[B]	6.4	3.45
ADEM	8/27/96	H-1	1.150	1.280	7.3	3.45
ADEM	8/27/96	HCRT-4	0.99	0.88	7.2	3.45
ADEM	8/27/96	HCRT-3	0.67	1.25	7.3	3.45
ADEM	8/27/96	HCRT-2	0.48	1.24	7.3	3.45
ADEM	8/27/96	HCRT-1	1.65	1.25	6.8	3.45
ADEM	8/28/96	H-1	1.57	1.40	6.7	3.45
ADEM	8/28/96	HCRT-4	2.31	1.59	7.4[C]	3.45
ADEM	8/28/96	HCRT-3	0.64	1.95	7.6[C]	3.45
ADEM	8/28/96	HCRT-2	0.39	2.50	7.8[C]	3.45
ADEM	**8/28/96**	**HCRT-1**	**16.99**	1.36	7.0[C]	3.45
ARA	5/9/00	Site 22	0.9	0.1[B]	6.8	3.45
ARA	5/9/00	Site 4	0.5[B]	0.1[B]	7.1	3.45
ARA	5/9/00	Site 5	0.4	0.1[B]	7.4	3.45
ARA	**5/17/00**	**Site 17[F]**	**7.3**	2.9	3.8	1.12
ADEM	Jun-00	HCRT-1	0.937	0.314	7.32	3.45
ADEM	Jun-00	H-1	0.104	0.093	7.59	3.45
ADEM	Jun-00	HCRT-2	0.08	0.2[B]	7.95	3.45
ADEM	Jun-00	HCRT-3	0.296	0.159	7.86	3.45
ARA	6/7/00	Site 21	0.5[B]	0.4	7.4	3.45
ARA	**6/7/00**	**Site 18[F]**	**14**	**0.3**	3.4	1.12
ARA	**6/7/00**	**Site 19[F]**	**17**	0.1[B]	6.3	3.45
ARA	6/28/00	Site 3	1	0.11	6.5	3.45
ADEM	Jul-00	HCRT-1	2.13	1.68	7.08	3.45
ADEM	Jul-00	H-1	0.181	0.052	7.24	3.45
ADEM	Jul-00	HCRT-2	0.1	0.059	7.62	3.45
ADEM	Jul-00	HCRT-3	0.051	0.118	7.71	3.45

ARA	7/19/00	Site 6	0.5^B	0.1^B	7.6	3.45
ARA	7/28/00	Site 2	0.5^B	0.1^B	D	3.45
ADEM	Aug-00	HCRT-1	0.067	0.023	D	3.45
ADEM	Aug-00	H-1	0.243	0.14	D	3.45
ADEM	Aug-00	HCRT-3	0.033	0.063	D	3.45
ADEM	Oct-00	HCRT-1	1.51	1.13	D	3.45
ADEM	Oct-00	H-1	0.112	0.056	D	3.45
ADEM	Oct-00	HCRT-2	0.089	0.098	D	3.45
ADEM	Oct-00	HCRT-3	1.07	0.619	D	3.45
ADEM	Jun-01	HCRT-1	0.974	0.295	D	3.45
ADEM	Jun-01	H-1	1.5	2.02	D	3.45
ADEM	Jun-01	HCRT-2	0.572	0.299	D	3.45
ADEM	Jun-01	HCRT-3	0.808	0.2^B	D	3.45
ADEM	Aug-01	HCRT-1	1.75	0.24	D	3.45
ADEM	Aug-01	H-1	0.301	0.2^B	D	3.45
ADEM	Aug-01	HCRT-2	0.316	0.2^B	D	3.45
ADEM	Aug-01	HCRT-3	0.205	0.2^B	D	3.45
ADEM	Oct-01	HCRT-1	0.653	0.2^B	7.59	3.45
ADEM	Oct-01	H-1	0.192	0.2^B	7.33	3.45
ADEM	Oct-01	HCRT-2	0.188	0.2^B	7.47	3.45
ADEM	Oct-01	HCRT-3	0.359	0.2^B	7.45	3.45
ADEM	Jun-02	HCRT-1	0.071	0.2^B	D	3.45
ADEM	Jun-02	H-1	0.553	0.478	D	3.45
ADEM	**Jun-02**	**HCRT-2**	**4.27**	6.6	D	3.45
ADEM	Aug-02	HCRT-1	2.05	0.586	6.85	3.45
ADEM	Aug-02	H-1	1.07	0.192	7.92	3.45
ADEM	Aug-02	HCRT-2	0.474	0.2^B	7.67	3.45
EPA	8/13/02	H-1	0.36	0.16	8.03	3.45
EPA	8/13/02	HC-1	0.58	0.24	7.31	3.45
EPA	8/13/02	HC-1a	0.22	0.05^B	7.78	3.45
EPA	8/13/02	HC-2a	0.32	0.05^B	8.08	3.45
EPA	8/13/02	HC-2b	0.084	0.05^B	7.85	3.45
EPA	8/13/02	HC-3	0.11	0.05^B	7.57	3.45
EPA	8/13/02	HC-2	0.17^A	0.05^B	7.81	3.45
EPA	8/13/02	CC-1	0.72	0.15	7.15	3.45
EPA	8/13/02	CC-2	1.3	0.42	6.64	3.45
EPA	8/13/02	KC-1	0.64	0.056	7.53	3.45
EPA	8/14/02	HCRT-2	0.26	0.064	8.27	3.45
EPA	8/14/02	HC-4	1.9	0.47	7.5	3.45
EPA	**8/14/02**	**BB-1[F]**	**4.8**	1.4	6.85	3.45
EPA	8/15/02	BE-1	0.76	0.14	6.62	3.45
ADEM	Oct-02	HCRT-1	1.86	2.14	D	3.45
ADEM	Oct-02	H-1	0.301	0.138	D	3.45
ADEM	Oct-02	HCRT-2	0.422	0.352	D	3.45
average of exceedances			**10.73**			**2.67**

TMDL % reduction in concentration for Hurricane Creek: 75%

North Fork Hurricane Creek

Agency	Sample Date	Site	Existing Iron Concentration mg/L	Existing Aluminum Concentration mg/L	pH	Applicable Target Concentration for Iron mg/L
ADEM	8/27/96	NFHT-1	0.590	1.350	7.4	3.45
ADEM	8/28/96	NFHT-1	2.110	1.350	7.6[C]	3.45
ARA	**5/17/00**	**Site 28**[G]	**2.3**	5.5	3.61	1.12
ARA	5/17/00	Site 31[G]	0.7	0.2	6.21	3.45
ARA	**5/17/00**	**Site 32**[G]	**13**	0.1[B]	5.82	1.12
ARA	**5/17/00**	**Site 33**[G]	**4**	25.5	3.28	1.12
ARA	**5/17/00**	**Site 36**[G]	**46**	9.3	3.02	1.12
ADEM	Jun-00	NFHT-1	0.053	0.132	8.08	3.45
ARA	6/22/00	Site 23	0.5[B]	0.1[B]	6.7	3.45
ARA	6/28/00	Site 24	0.2	0.36	7.4	3.45
ADEM	Jul-00	NFHT-1	0.211	0.159	7.97	3.45
ADEM	Aug-00	NFHT-1	1.4	0.935	D	3.45
ADEM	Oct-00	NFHT-1	0.14	0.221	D	3.45
ARA	**05/09/01**	**HC01**[G]	**93**	0.01	3.0	1.12
ARA	**05/09/01**	**HC02**[G]	**48**	0.02	3.2	1.12
ARA	**05/09/01**	**HC03**[G]	**54**	0.01	3.3	1.12
ADEM	Jun-01	NFHT-1	0.662	0.2[B]	D	3.45
ADEM	Aug-01	NFHT-1	0.213	0.271	D	3.45
ADEM	Oct-01	NFHT-1	0.171	0.254	7.61	3.45
ADEM	Jun-02	NFHT-1	1.66	1.13	D	3.45
ADEM	Aug-02	NFHT-1	1.52	0.174	7.98	3.45
EPA	8/14/02	NFHT-1	0.094	0.11	8.29	3.45
EPA	**8/14/02**	**WC-2**[G]	**2.6**	11	3.11	1.12
EPA	8/14/02	WCUT-2[G]	0.12	2.8	4.15	1.12
ARA	**08/26/02**	**HC02**[G]	**90**	3	3.5	1.12
ARA	**08/26/02**	**HC04**[G]	**25**	2.9	3	1.12
ARA	08/26/02	HC05	0.5[B]	0.02	7.3	3.45
ADEM	Oct-02	NFHT-1	0.439	0.292	D	3.45
ARA	**11/12/02**	**HC01**[G]	**31**	8.2	3.32	1.12
ARA	**11/12/02**	**HC02**[G]	**26**	13	3.52	1.12
ARA	**11/12/02**	**HC04a**[G]	**25**	5.1	3.40	1.12
ARA	11/12/02	HC05	1.1	0.1[B]	6.78	3.45
ARA	**1/9/03**	**HC01**[G]	**96**	0.63	3.06	1.12
ARA	**1/9/03**	**HC02**[G]	**55**	0.51	3.18	1.12
ARA	**1/9/03**	**HC04a**[G]	**37**	0.85	3.18	1.12
ARA	1/9/03	HC05	1.8	0.25	6.89	3.45
ARA	**3/25/03**	**HC01**[G]	**116**	0.38	3.02	1.12
ARA	**3/25/03**	**HC02**[G]	**45**	0.36	3.09	1.12
ARA	**3/25/03**	**HC04a**[G]	**51**	0.36	3.07	1.12
ARA	3/25/03	HC05	1.4	0.05	6.84	3.45
average of exceedances			**45.3**			**1.12**

TMDL % reduction in concentration for Hurricane Creek: 98%

Little Hurricane Creek

Agency	Sample Date	Site	Existing Iron Concentration mg/L	Existing Aluminum Concentration mg/L	pH	Applicable Target Concentration for Iron mg/L
ADEM	6/11/96	LHCT-2B	1.22	0.592	7.4	3.45
ADEM	6/11/96	LHCT-2A	0.963	0.496	7.4	3.45
ADEM	6/12/96	LHCT-2B	1.25	0.404	7.2	3.45
ADEM	6/12/96	LHCT-2A	0.938	0.268	6.7	3.45
ADEM	8/27/96	LHCT-2B	1.470	1.59	7.2	3.45
ADEM	8/27/96	LHCT-2A	0.69[A]	1.3[A]	7.1	3.45
ADEM	8/28/96	LHCT-2A	0.65	18.92	7.4	3.45
ADEM	**8/28/96**	**LHCT-2B**	**24.6**[A]	**39.6**[A]	7.5[C]	3.45
ADEM	Jun-00	LHCT-1	0.564	0.304	7.54	3.45
ADEM	Jul-00	LHCT-1	0.544	0.165	7.86	3.45
ARA	7/28/00	Site 20	0.5[B]	0.1[B]	D	3.45
ADEM	Oct-00	LHCT-1	1.94	1.41	D	3.45
ADEM	Jun-01	LHCT-1	0.955	0.2	D	3.45
ADEM	Aug-01	LHCT-1	0.966	0.2	D	3.45
ADEM	Oct-01	LHCT-1	0.369	0.2	7.2	3.45
ADEM	Jun-02	LHCT-1	0.35	0.193	D	3.45
ADEM	Aug-02	LHCT-1	0.644	0.18	7.25	3.45
EPA	8/14/02	LHC-1	0.41	0.05[B]	7.2	3.45
EPA	8/14/02	LHC-4	0.76	0.2[H]	7.77	3.45
ADEM	Oct-02	LHCT-1	0.696	0.304	D	3.45
average of exceedances			**24.6**			**3.45**

TMDL % reduction in concentration for Hurricane Creek: 86%

NOTES
EPA = Environmental Protection Agency
ADEM = Alabama Department of Environmental Management
ARA = Alabama Rivers Alliance
A = average of duplicates
B = below or at detection. Value is equal to the detection limit.
C = pH measured in the laboratory
D = missing pH value. Because every other measured pH in those segments (not including tributaries) is above 6, the missing values were also assumed to be above 6.
E = determined using Hach colorimeter.
F = sites located in the Blanchet Branch tributary
G = sites located in the Weldon Creek area, upstream of North Fork
H = estimated value

APPENDIX A, continued: Data and TMDL Calculations for Copper

The existing conditions and targets from which the TMDL percent reductions are calculated are the averages of the exceedances, which are shown in bold type. The applicable target concentration for copper is calculated from the measured hardness of the sample. It should be noted that copper was tested for on additional samples collected by both ADEM and EPA on other dates, but **only detected levels of total copper are presented in the table.**

Little Hurricane Creek

Agency	Sample Date	Site	Existing Total Copper Concentration mg/L	Hardness mg/L $CaCO_3$	Applicable (chronic) Target Concentration for Copper mg/L
ADEM	**8/27/96**	**LHCT-2B**	**0.006**	42	0.0056
ADEM	8/27/96	LHCT-2A	0.002	49	0.0064
ADEM	**8/28/96**	**LHCT-2B**	**0.017**	65	0.0082
ADEM	**8/28/96**	**LHCT-2A**	**0.012**	64	0.0081
ADEM	**Oct-02**	**LHCT-1**	**0.016**	100	0.0118
average of exceedances			**0.013**		**0.0084**
TMDL % reduction in concentration for Little Hurricane Creek:					**33%**

NOTES

ADEM = Alabama Department of Environmental Management

A = Average of duplicates

APPENDIX A, continued: Data and TMDL Calculations for Turbidity

The existing condition used to calculate the TMDL percent reduction is equal to the highest exceedance. Exceedances of the turbidity target are shown in bold type. As with the metals TMDLs, data from tributaries to Hurricane Creek were considered, although in the case of turbidity, they did not affect the required percent reduction.

Hurricane Creek

Agency	Sample Date	Site	Existing Turbidity NTU	Applicable Target Turbidity NTU
ADEM	6/11/96	H-1	3.9	60.8
ADEM	6/11/96	HCRT-4	3.3	60.8
ADEM	**6/11/96**	**HCRT-3**	**90**[A]	60.8
ADEM	6/11/96	HCRT-2	7.8	60.8
ADEM	6/11/96	HCRT-1	33	60.8
ADEM	6/12/96	H-1	6.4	60.8
ADEM	6/12/96	HCRT-4	5.6	60.8
ADEM	6/12/96	HCRT-3	49	60.8
ADEM	6/12/96	HCRT-2	19	60.8
ADEM	6/12/96	HCRT-1	20	60.8
ADEM	8/27/96	H-1	60.7	60.8
ADEM	8/27/96	HCRT-4	32.4	60.8
ADEM	8/27/96	HCRT-3	24.6	60.8
ADEM	8/27/96	HCRT-2	9.7	60.8
ADEM	8/27/96	HCRT-1	28.0	60.8
ADEM	8/28/96	H-1	41.3	60.8
ADEM	8/28/96	HCRT-4	47.9	60.8
ADEM	8/28/96	HCRT-3	40.2	60.8
ADEM	8/28/96	HCRT-2	12.7	60.8
ADEM	8/28/96	HCRT-1	33.9	60.8
ADEM	Jun-00	H-1	1	60.8
ADEM	Jun-00	HCRT-3	3	60.8
ADEM	Jun-00	HCRT-1	8	60.8
ADEM	Jun-00	HCRT-2	1	60.8
ADEM	Jul-00	H-1	2.91	60.8
ADEM	Jul-00	HCRT-3	3.42	60.8
ADEM	Jul-00	HCRT-1	25	60.8
ADEM	Jul-00	HCRT-2	1.11	60.8
ADEM	Oct-01	H-1	1.3	60.8
ADEM	Oct-01	HCRT-3	2.1	60.8
ADEM	Oct-01	HCRT-1	11	60.8
ADEM	Oct-01	HCRT-2	2	60.8
ADEM	Aug-02	H-1	3.7	60.8
ADEM	**Aug-02**	**HCRT-1**	**76.6**	60.8
ADEM	Aug-02	HCRT-2	3.3	60.8
EPA	8/13/02	HC-1a	4.66	60.8

EPA	8/13/02	HC-2b	1.55	60.8
EPA	8/13/02	HC-3	1.68	60.8
EPA	8/13/02	HC-2	2.05	60.8
EPA	8/13/02	HCRT-2	2.39	60.8
EPA	8/13/02	HC-4	28.5	60.8
EPA	8/13/02	HC-2a	2.91	60.8
EPA	8/13/02	KC-1	3.12	60.8
EPA	8/14/02	BB-1	24.8	60.8
EPA	8/15/02	H-1	7.51	60.8
EPA	8/15/02	HC-1	8.62	60.8
EPA	8/15/02	CC-1	8.36	60.8
EPA	8/15/02	CC-2	20.6	60.8
EPA	8/15/02	BE-1	5.01	60.8
average of exceedances			**90**	**60.8**
TMDL % reduction in turbidity for Hurricane Creek:				**32%**

NOTES

ADEM = Alabama Department of Environmental Management

EPA = Environmental Protection Agency

A = This data value was qualified as greater than the given value.

APPENDIX A, continued: Data and TMDL Calculations for Pathogens

The existing conditions used to calculate the TMDL percent reductions are equal to the average of the exceedances, which are shown in bold type. As with the metals TMDLs, any available data from tributaries to the listed segments were considered, although in the case of fecal coliform, they did not affect the required percent reductions.

Hurricane Creek

Agency	Sample Date	Site	Existing Fecal Coliform Concentration colonies/100 ml	Applicable Fecal Coliform Concentration colonies/100 ml
ADEM	6/12/96	H-1	960	2000
ADEM	6/12/96	HCRT-4	132	2000
ADEM	6/12/96	HCRT-3	88	2000
ADEM	6/12/96	HCRT-2	43	2000
ADEM	6/12/96	HCRT-1	45	2000
ADEM	8/28/96	H-1	1120	2000
ADEM	8/28/96	HCRT-4	530	2000
ADEM	8/28/96	HCRT-3	320	2000
ADEM	8/28/96	HCRT-2	266	2000
ADEM	8/28/96	HCRT-1	380	2000
ADEM	June-00	HCRT-1	90	2000
ADEM	June-00	H-1	95	2000
ADEM	June-00	HCRT-2	52	2000
ADEM	June-00	HCRT-3	43	2000
ADEM	July-00	HCRT-1	21	2000
ADEM	July-00	H-1	760	2000
ADEM	July-00	HCRT-2	24	2000
ADEM	July-00	HCRT-3	6	2000
ADEM	August-00	HCRT-1	5	2000
ADEM	August-00	H-1	24	2000
ADEM	August-00	HCRT-3	14	2000
ADEM	October-00	HCRT-1	26	2000
ADEM	October-00	H-1	71	2000
ADEM	October-00	HCRT-2	19	2000
ADEM	October-00	HCRT-3	13	2000
ADEM	June-01	HCRT-1	210	2000
ADEM	June-01	H-1	450	2000
ADEM	June-01	HCRT-2	107[B]	2000
ADEM	August-01	HCRT-1	20	2000
ADEM	August-01	HCRT-2	128	2000
ADEM	October-01	HCRT-1	112	2000
ADEM	October-01	H-1	60	2000
ADEM	October-01	HCRT-2	24	2000
ADEM	October-01	HCRT-3	80	2000
ADEM	June-02	HCRT-1	170	2000
ADEM	June-02	HCRT-2	160	2000

ADEM	August-02	HCRT-1	18	2000
ADEM	August-02	H-1	276	2000
ADEM	August-02	HCRT-2	210	2000
EPA	8/13/02	H-1	74	2000
EPA	8/13/02	HC-1	80	2000
EPA	8/13/02	HC-1a	70	2000
EPA	8/13/02	HC-2a	124	2000
EPA	8/13/02	HC-3	54	2000
EPA	8/13/02	HC-2	32	2000
EPA	8/13/02	CC-1	150	2000
EPA	8/13/02	CC-2	780	2000
EPA	8/13/02	KC-1	308	2000
EPA	8/14/02	HCRT-2	180	2000
EPA	8/14/02	HC-4	38	2000
EPA	8/14/02	BB-1	55[B]	2000
EPA	8/15/02	BE-1	184[B]	2000
ADEM	**October-02**	**HCRT-1**	**6000**[A]	2000
ADEM	October-02	H-1	80	2000
ADEM	October-02	HCRT-2	250	2000
average of exceedances			**6000**	**2000**
TMDL % reduction in pathogens in Hurricane Creek:				**67%**

Little Hurricane Creek

Agency	Sample Date	Site	Existing Fecal Coliform Concentration colonies/100 ml	Applicable Target Fecal Coliform Concentration colonies/100 ml
ADEM	6/12/96	LHCT-2B	148	2000
ADEM	6/12/96	LHCT-2A	174	2000
ADEM	**8/28/96**	**LHCT-2B**	**2400**	2000
ADEM	**8/28/96**	**LHCT-2A**	**2900**	2000
ADEM	June-00	LHCT-1	120	2000
ADEM	October-00	LHCT-1	144	2000
ADEM	June-01	LHCT-1	44	2000
ADEM	August-01	LHCT-1	78	2000
ADEM	October-01	LHCT-1	21	2000
ADEM	August-02	LHCT-1	136	2000
EPA	8/14/02	LHC-1	76	2000
EPA	8/14/02	LHC-4	600[A]	2000
ADEM	October-02	LHCT-1	84	2000
average of exceedances			**2650**	**2000**
TMDL % reduction in pathogens in Little Hurricane Creek:				**25%**

NOTES

ADEM = Alabama Department of Environmental Management
EPA = Environmental Protection Agency
A = Value qualified as greater than the number provided.
B = Average of two samples.